PATENT SPECIFICATION

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements relating to Pneumatic Tyres

We, AMERICAN MACHINE & FOUNDRY CO., a Corporation organised under the Laws of the State of New Jersey, United States of America, of 261 Madison Avenue, in the City and State of New York, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed to be particularly described in and by the following statement:—

This invention relates to machines for depositing elastomeric material on tyre casings and is concerned with machines for use in retreading vehicle tyres, as well as machines for use in the initial manufacture of vehicle tyres, or machines capable of performing both the above functions.

The invention also relates to methods of making or retreading tyres using such machines, and to tyres made or retreaded by the use of such machines.

The invention is an improvement in or modification of that described and claimed in the present applicants' British patent specification No. 1,005,745.

According to one aspect of the present invention a machine for depositing a variable thickness layer of elastomeric material on a tyre casing comprises means for supporting the casing, a feeding head for applying to the casing a ribbon of the elastomeric material of which the width is several times the thickness, means for rotating the casing about its axis, referred to herein as the spin axis, to wind on the casing a winding comprising a substantial number of turns as the casing rotates relatively to the feeding head, means for moving the feeding head transversely relatively to the casing, referred to herein as azimuth movement, from one side to the other of the mid-circumferential plane of the casing, to produce a winding which extends from a position on one side of the mid-circumferential plane of the casing across the said mid-circumferential plane to a position on its other side, and of which successive turns partially overlap, and means for automatically varying the azimuth movement per spin revolution of the casing to cause the turns of the winding to overlap to a varying degree, thereby varying the thickness of the layer. The width of the ribbon may, for example, be between five and thirty times its thickness and should be greater than the maximum thickness of the layer deposited on the casing by winding the ribbon along the outer surface of the casing. Naturally the thickness of the ribbon cannot be greater than the minimum thickness of the layer, so that the ratio of width to thickness of the ribbon will be to some extent dependent on the ratio of maximum to minimum thickness required in the layer.

In one form of the invention the azimuth movement is a movement of relative translation along the axis of the casing and this may be used for winding a casing of cylindrical form, for example for a new tyre. In another form of the invention the machine is adapted for winding a casing of generally part toroidal form, for example, for retreading, in which case the azimuth movement may be a movement of relative rotation about an azimuth axis tangential to the circular axis of the toroid.

In the disclosed machines used for processing relatively small tyres, the stitching point remains substantially stationary and the azimuth movement is imparted to the casing.

The ribbon is applied by a stitching head which is movable towards and away from the casing, means being provided for applying pressure to the stitching head to press the ribbon onto the casing. The stitching head has stitching rollers, which are in-

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depende[illegible] movable towards and away from the casing and urged towards it by fluid pressure, through which the ribbon stitching pressure is applied to the ribbon. In one embodiment of the invention, the stitching head also carries a driven spin wheel which serves to drive the casing about the spin axis. In the second embodiment of the invention, which is the preferred version, a variable speed direct current motor is coupled through a speed reducing gear box to the spin axis. The speed of the motor is then controlled by an electronic programmer to make the peripheral speed of the casing continuously equal to the speed of extrusion of the ribbon by the local extruder. In this manner, the dimensions of the ribbon remain unchanged between its extrusion and stitching to the casing.

For enabling the machine to be employed for casings of various sizes, means is provided for adjusting the spin axis of the casing towards and away from the azimuth axis so as to make the azimuth axis be tangent to the circular central axis of the toroidally shaped casing. Thus in one arrangement, in which the azimuth axis is vertical, the means for supporting the casing comprise an azimuth shaft mounted to turn about its axis, a radial arm carried by the azimuth shaft, a column supported by and projecting up from the radial arm, and an adjustable arm pivoted at its lower end on the radial arm and carrying a spin bearing and means for supporting the casing on the spin bearing, and means for adjusting the angular position of the adjustable arm relative to the upstanding column.

The customary method of applying a layer of elastomeric material of a tyre casing to constitute a new tread and side walls has hitherto involved the employment of a band of uncured elastomer known as camelback. As the name implies, this is shaped with two humps to constitute the shoulder portions of the tread, a slightly thinner crown portion between the shoulders, and side wall portions that are thinner still on either side of the shoulders. For retreading, the casing is buffed, sprayed with a cement, and a length of camelback, corresponding to its circumference, is stitched, i.e., initially adhered to the buffed surface, and then vulcanised or cured in a mould having a removable matrix shaped to imprint the desired tread pattern on the camelback whilst shaping it to the casing and firmly securing it thereto. Such camelback is preformed by extruding the material through a die of the required cross section. It will be appreciated that in order to be able to deal with the large number of sizes and sections of tyres that exist, a retreader must stock, or be capable of rapidly obtaining, a great variety of sizes and shapes of camelback.

The present invention enables one to deposit a variable thickness elastomeric material on the casing and to control this variable thickness with very high degree of precision with the aid of an electronic programmer. It thus becomes possible to obtain the precise sections required for an almost unlimited range of different types of tyres (within limits of size) without the necessity for any camelback and using a strip of material of standard section, for example, 1" by 0.1", the thickness of the layer being controlled automatically by varying the extent of overlap between successive turns. The size of a suitable ribbon for practicing the disclosed methods will be discussed more in detail later. Suffice it to say at this time that the width of the ribbon should be larger than the maximum thickness of the layer to be deposited on the casing and its thickness should not be much larger than the minimum thickness of the layer. This will become more apparent from what follows.

The method of locally converting raw elastomer, which may be furnished in a slab form, into a locally extruded hot, tacky and pliable ribbon at the very time such ribbon is wound on a casing has a number of very important advantages. First, the cost of the elastomer in a slab form is much cheaper. The expense of specially extruding the camelback is eliminated, and in addition, camelback is normally mounted on a polyethylene backing with an expensive soft rubber adhesive layer, whilst the packing and transporting of camelback is generally more costly than that of bulk material. Second, the retreader does not have to lock up large sums of capital and substantial storage space in holding a supply of camelback of many different shapes and sizes. Moreover, the shelf life of the uncured material is limited, so that storage of shapes of camelback seldom required is particularly unsatisfactory. Moreover, there is an unavoidable splice at the matching of the two ends of a length of camelback, usually resulting in unbalance of the tyre.

The basic principle of all methods disclosed here, the principle which is common to all disclosed methods is to wind the ribbon have a substantially rectangular cross-section, and preferably with two top corners rounded off, so that the ribbon follows essentially a variable pitch spiral or helix with the succeeding turns overlapping the corresponding preceding turns to a variable degree, such as from 5% up to 100%. Because of such variable overlap, the transverse dimension of the ribbon, i.e., its width, forms a variable angle of inclination with the adjacent face of the casing, this angle of inclination, essentially being equal to zero when the overlap is 5% and in the order

of 45°-60° when the ov[illegible] is in the order of 60%-80%.

The variable pitch winding of the above type can be produced by using several methods which are described below.

For example, in one method the winding may be regarded as divided into a number of sectors including two shoulders and a crown, the overlap and thickness being greater in the shoulder sectors than in the crown sector. In carrying out recapping, a crown, or two shoulder sectors and the crown, may be the only sectors, but in general, whether for making new tyres or for retreading, the winding will also include two side wall sectors in which the overlap and thickness is less than it is in the crown sector. The winding may also include a beauty ring wound without azimuth movement on one or each side. Such a scuff preventing beauty ring is intended to protect the side wall from being damaged or disfigured, for example when the tyre contacts a kerb. Often two or more beauty rings will be included on one or each side wound successively without azimuth movement and hence with 100% overlap.

Broadly speaking, the machines described below employ three different methods of winding, which may conveniently be referred to as Method 1, Method 2 and Method 3. In Method 1 the azimuth movement per spin revolution, and hence the overlap between successive turns, assuming constant ribbon thickness, is kept constant in each sector but is changed between one sector and another. In Method 2 the azimuth movement per spin revolution may be varied during individual sectors of the winding.

Methods 1 and 2 will be referred to later also as variable speed methods since the speed of the azimuth rotation is varied as an inverse function of the desired thickness of the elastomeric layer.

In Method 3 the azimuth movement occurs at substantially constant speed but only for a fraction of each spin revolution, the said fraction being varied to vary the amount of the azimuth movement per spin revolution. Preferably, the azimuth movement begins at the same point in each revolution and lasts for a variable length of time. This length of time is controlled and is determined automatically by an electronic programmer. In Method 3 the azimuth movement, therefore, is a start-stop movement.

In Method 1 any azimuth movement occurring during the spin revolution occurs throughout that revolution, the speed of azimuth movement being variable to vary the amount of the azimuth movement obtained during any given spin revolution. The casing in this method nevertheless is electronically subdivided into several sectors, such as the previously men[illegible]d two side wall sectors, two shoulder [illegible]s and the central crown sector, five sectors in all, and the azimuth speed is changed from sector to sector, depending on the desired thickness of the elastomeric layer within each individual sector. The azimuth movement is a continuous movement and the speed of the azimuth movement is varied in accordance with the required thickness of the elastomeric layer to be deposited on the casing.

In Method 2 the azimuth movement is controlled by the electronic programmer so that the speed of the azimuth motor can be changed at any moment since the speed of the motor is controlled by a variable height, or a variable amplitude cam, the height of the cam corresponding to the height, or the thickness, of the variable thickness layer to be deposited on the casing at any given point on that layer. Therefore, the speed of the azimuth motor is constant as long as the thickness of the layer is constant and varies if the thickness of the layer varies.

Various forms of control may be incorporated for effecting the winding by each of the methods referred to, and many features will be apparent from the specific description given below with reference to the drawings. Some important features will be briefly referred to.

As already indicated, it is preferred that the machine should include an extruder from which the ribbon is supplied in a hot state direct to the casing. In this state the conditions are particularly favourable for the adhesion of the ribbon to the casing and to itself without the necessity for providing any special adhesive layer. Where the size of the plant justifies it, the material may be supplied direct to the extruder from a Banbury mixer and sheeting mills following the mixer. In such cases the machine may include a chopper for automatically chopping slabs of the elastomeric material into strips and feeding the strips to the extruder, and means for controlling the chopper automatically in accordance with the rate at which the extruder accepts the strips. The machine includes means for controlling the spin speed in response to the rate of supply of ribbon from the extruder.

Preferably, the machine includes means dependent upon the ribbon thickness for modifying the azimuth movement per spin revolution. The ribbon thickness is liable to vary slightly if there is a variation in the temperature, composition and uniformity of prior mastication of the stock fed to the extruder and this, in turn, will cause the thickness of the deposited layer to depart from the desired section, or thickness if not allowed for. By providing a ribbon thickness transducer giving a signal dependent upon the thickness of the ribbon approach-

ing the [illegible]ching point, and causing the signal to modify the azimuth movement per spin revolution in an appropriate manner, the thickness can be made to follow the desired section, or thickness, closely. In general, the width of the ribbon will vary at the same time as the thickness, and the control in accordance with ribbon thickness can also be made to take into account the effect of variation of ribbon width on the thickness of the deposited layer.

An additional ribbon thickness transducer may also be employed to give a continuous indication on its scale of ribbon thickness, so that if a major variation has occurred, which is beyond the range of normal operation of the first transducer, then such change in thickness may be corrected by manual adjustment of the extrusion dye of the extruder.

The machines may include a programme unit having interchangeable keys corresponding to different types of tyre, and scanning means for scanning a selected key in synchronism with the azimuth movement, the key being formed to actuate the scanning means in the azimuth movement to modify the rate of azimuth movement per spin revolution. For example, the key may conveniently be in the form of a plate, which will be referred to as a programme card, which may have projections or recesses to actuate switches associated with the scanning means at appropriate points of said key. In any of the three methods referred to above, the key may actuate scanning switch contacts at an azimuth starting position appropriate for starting the winding, which contacts may control a starting circuit to prevent starting of the programme except when the casing is in the azimuth starting position and may also control an indicator (e.g. a lamp) to indicate to an operator that the casing is in the azimuth starting position.

Preferably, the machine also includes a spin switch arranged to be actuated when the casing is at a predetermined spin starting position about the spin axis. The spin switch may control a starting circuit to prevent starting of the programme except when the casing is in the spin starting position, and may also control an indicator (e.g. a lamp) to indicate to an operator that the casing is in the spin starting position.

The machine conveniently also includes a stepping switch having a number of positions corresponding to different stages of the winding cycle, and means responsive to a stepping pulse for moving it from one position to the next. At certain stages such stepping pulses may be produced by the spin switch to control portions of the programme during which there is no azimuth movement, for example a first turn, a last turn, or one or more beauty rings.

For winding by Method No. 2, as mentioned previously, the key may be in the form of a variable height cam co-operating with a cam follower to control the movement of a transducer which controls the azimuth speed.

For winding by Methods Nos. 1 and 3 the programme card may include means for delivering a stepping pulse at the beginning of each sector to move it on to the appropriate position for winding that sector.

The programme card may also have non-circular apertures, referred to as interlocking apertures, shaped to fit over manual adjusting members, referred to as knobs, only when such members are in predetermined positions.

For winding by Method 1 or Method 2 the azimuth movement may be produced by a d.c. motor supplied through a semi-conductor (e.g. silicon) rectifier controlled for example by the output of a magnetic amplifier, to vary its speed.

The speed of the azimuth motor may be controlled by a signal including a component supplied by a spin tachometer, so that the azimuth speed varies with the spin speed. The signal may also include a component supplied by a ribbon thickness transducer, to allow for ribbon thickness. The signal may also include a component supplied by an azimuth tachometer to provide negative feed back.

The invention may be performed in various ways but certain specific embodiments will be described by way of example with reference to the accompanying drawings in which:

Figure 1 is a transverse section of a tyre casing surrounded by matrix showing a variable thickness elastomeric layer wound on the casing prior to curing;

Figure 2 is a transverse section on the elastomeric layer shown in Figure 1 but developed along a straight line;

Figure 3 is a plan view of a portion of the layer, wound by what will be referred to as Method 1 or Method 2, developed about the wheel axis;

Figure 4 is a view similar to Figure 3 but showing a winding performed by what will be referred to as Method No. 3;

Figure 5 is a side elevation of a machine for retreading used tyres by either Method No. 1 or Method No. 2;

Figure 6 is a plan view of the machine shown in Figure 5;

Figure 7 is a side elevation of part of the machine showing the measurement of the radius of a casing;

Figure 8 is a perspective view of a pneumatic stitcher;

Figure 9 is a sectional plan on the line 9-9 of Figure 5 showing the azimuth motor

and drive;

Figure 10 is a front view of the control panel;

Figure 11 is an enlarged sectional side elevation of part of the control panel;

Figure 12 is a view of a control card;

Figure 13 is a fragmentary sectional view of the jaws of a pair of pliers for indenting the control card;

Figure 14 is an elevation partly in section of the spin axle, spin switches and spin tachometer;

Figure 15 is a perspective view of the spin switch cam and tachometer gears;

Figure 16 is a diagrammatic perspective view of the stepping switch;

Figure 17 is a table illustrating the sequence of operations of the stepping switch for winding the pattern shown in Figures 1 to 3;

Figure 18 is a circuit diagram of the complete machine, certain portions being shown as blocks;

Figure 19 is a circuit diagram of the spin motor control appearing as a block in Figure 18;

Figure 20 is a circuit diagram of the azimuth speed control appearing as a block in Figure 18;

Figure 21 is a circuit diagram of the azimuth and stepping relay circuits appearing as a block in Figure 18;

Figure 22 is a perspective view of a machine for making new tyres;

Figure 23 is a cross-section of the winding on a new tyre casing;

Figure 24 is a table of the sequence of operations of the stepping switch for producing the winding of Figure 23;

Figure 25 is a sectional view of a new tyre casing with two variable thickness layers deposited on it;

Figure 26 is a sectional view of a new or used tyre casing with a single variable thickness layer including only the crown and shoulders;

Figure 27 is a table showing the sequence of operations of the stepping switch for producing the winding of Figure 26, or the second layer of Figure 25;

Figure 28 is part of a circuit diagram for producing the windings shown in Figures 25 and 26 by Method No. 1;

Figures 29 and 30 are views of two programme cards for winding the two layers of Figure 25 using Method No. 1;

Figure 31 is an elevation of a cam and transducer for effecting continuous control of the azimuth speed by Method No. 2;

Figure 32 is a circuit diagram of the machine employing Method No. 2, certain portions being shown as blocks;

Figure 33 is a circuit diagram of the azimuth speed control circuit using Method No. 2, appearing as a block in Figure 32;

Figure 34 is a circuit diagram of the azimuth stepping relay circuits using Method No. 2, appearing as a block in Figure 32;

Figure 35 is a table of the operation of the stepping switch corresponding to Figures 31 to 34;

Figure 36 is a view similar to Figure 31 of a cam for producing a winding on a new tyre casing such as that of Figure 23, by Method No. 2;

Figure 37 is a circuit diagram of an arrangement for producing the winding of Figure 23 using Method No. 2;

Figure 38 is a table of operations of the stepping switch for producing the winding of Figure 23 by Method No. 2, and

Figure 39 is a circuit diagram of the azimuth and stepping relay circuits and azimuth timer circuit for producing the winding of Figure 25 using Method No. 3.

VARIABLE PITCH COMPOSITE SPIRAL WINDING

Figure 1 is a cross section of a typical tyre casing 150 received in a curing matrix 149, and indicates clearly the variation of thickness of the space that has to be filled with the uncured elastomer layer, in order that the matrix will be completely filled when compression moulding is effected to form the actual tread pattern, consolidate the layer, cure it, and secure it firmly to the casing. As indicated in Figure 1 this variation of thickness is obtained by winding the layer from a ribbon of constant cross section, for example 1" by 1/10", in a single winding. The variation of thickness across the casing is obtained by automatically varying the pitch of the winding, and therefore the extent of overlap of successive turns, as the winding proceeds. Figure 1 clearly illustrates how the thickness of the layer is dependent on the pitch and overlap of the winding.

It has been found that in many cases satisfactory results can be obtained by regarding the layer as divided into the five sectors A, B, C, D and E shown in Figure 1, and keeping the pitch constant throughout each of these sectors, as long as the thickness of the ribbon is constant. The sectors referred to comprise the two side wall sectors A and E in which the thickness is a minimum, the two shoulder sectors B and D in which the thickness is a maximum, and a crown sector C of intermediate thickness. It is found that the same pitch may be used for both side walls, namely sectors A and E. In addition the two side wall sectors A and E may include scuff preventing beauty rings F and G which may have one, two or three layers of ribbon deposited one on top of the other (i.e., with zero pitch or 100% overlap). The ribbon of elastomeric material is applied to the five sectors in a single pass of many spin revolutions in one

complete spiral winding of which the thickness is varied between one sector and another by varying the percentage of overlap between adjacent turns from 5% to 100%, the 100% overlap taking place only if the layer also includes the beauty rings. The whole layer is wound with a ribbon of constant cross section (for example 1"×1/8").

For this purpose the casing is mounted so that it can be rotated about its own axis, referred to as its spin axis, and so that a feeding movement, referred to as azimuth motion, can be imparted to it about an axis tangential to a circle passing through the approxicentre 0 of the section of the casing. As will be clear from Figure 1, the thickness of tread material built up will depend upon the extent to which successive turns of ribbon overlap, and this will depend upon the amount of azimuth motion taking place in each revolution of the casing about the spin axis.

Broadly speaking, there are three methods of varying the pitch of the winding, which will be referred to for simplicity as Methods Nos. 1, 2 and 3.

In Method No. 1, employed in the machine described with reference to Figures 5 to 30, the rate of azimuth movement is variable, for example, by employing a variable speed motor to produce the azimuth movement, but is kept constant within each sector as long as the thickness of the ribbon is constant, and the speed of the azimuth movement is changed only when passing from one sector to another.

In Method No. 2, described in connection with Figures 31 to 38, the speed of azimuth movement is continuously variable as long as the thickness of the layer is continuously variable. In this method the speed of the variable speed motor is controlled by means of a variable height cam, and therefore, the speed of the azimuth movement can be changed by the electronic programmer at any desired moment. There is no subdivision of the casing into sectors.

In a third method employed in the modification described with reference to Figure 39, the azimuth movement occurs in steps of varying time duration, the rate of movement in each step remaining substantially constant throughout the winding. Thus the azimuth movement is produced at a greater rate than that which would have been required if the pitch were a continuous, uniform pitch, but such accelerated azimuth movement takes place only for a variable, controllable fraction of a revolution about the spin axis. The total azimuth movement during each spin revolution, and hence the pitch of the winding, is varied by varying the interval of time during which the constant speed azimuth movement takes place. The azimuth movement, therefore, is a start-stop, constant speed movement which lasts for a controllable interval of time in Method 3.

Figure 2 shows the winding of Figure 1 developed or flattened out about the azimuth axis, whilst Figures 3 and 4 show a portion of the winding developed about both the azimuth axis and the spin axis so as to illustrate the difference between the windings produced by Methods 1 and 3. Thus in Figure 3 it will be seen that in each sector the lines representing the edges of successive turns are all parallel to each other, but are all inclined to the longitudinal centre line, but the inclination of, for example, the lines 51 in sectors A and E representing the ratio of azimuth speed to spin speed, is different from the inclination of the lines 52 in sector C, for example. This follows from the fact that the azimuth speed is constant throughout the spin revolution and remains constant within each sector but is altered between one sector and the next.

On the other hand in Figure 4, representing a winding obtained by Method 3, it will be noted that certain parts 53 to 57 of the edges of the turns, representing a portion of each spin revolution, which portion may be in the order of from 30° to 120°, are all parallel to one another at a certain inclination to the longitudinal centre line whilst other parts 58 to 62 representing the remainder of each spin revolution, which is the remaining 330° to 240°, are parallel to the longitudinal centre line since at this time there is no azimuth rotation. Moreover, it will be noted that in the side wall sectors A and E the inclined portions 53 and 57 extend very much further than lines 55 in the crown sector C, and in the latter they extend slightly further than those 54 and 56 in the shoulder sectors B and D. In other words, the total amount of azimuth movement that occurs in each spin revolution in sector A is very much greater than in sector C, so that the pitch is greater, and the extent of overlap, and hence the thickness, is less.

Thus during a large portion of a revolution of 360° about the spin axis, say 240°, there is no azimuth movement and the ribbon is laid in what may be called a spiral or helix of zero pitch, whilst during the remaining portion perhaps of 120°, azimuth movement occurs at a constant speed and the ribbon is laid in a spiral or helix of constant pitch as long as the spin speed remains constant.

It will be noted in Figure 4 that the azimuth movement of all five sectors starts at the same point of the circumference of the casing, namely that represented by the line 63 lying parallel to the spin axis. The side wall portions A and E of the tyre are to be of minimum thickness and accordingly

the azimuth motion is continued for the greatest spin angle so that the overlap will be a minimum, namely to the point on the circumference represented by the line 64. Accordingly, the lines 53 representing the left hand side wall sector, and the lines 57 representing the right hand side wall sector, are spaced apart to a maximum extent representing the maximum pitch, minimum percentage of overlap, zero angle of inclination and minimum thickness. For the crown of the tyre an intermediate thickness is required and this is obtained by continuing the azimuth rotation as far as the line 65, whilst for the two shoulder portions B and D requiring the maximum thickness, the azimuth rotation is continued to the lines 66 and 67 respectively. In these sectors, because of the limited azimuth rotation, there is minimum pitch, very high percentage of overlap, maximum angle of inclination and a large amount of material is deposited since the successive turns of ribbon are almost directly superimposed on one another.

Although sectors B and D are symmetrical and have substantially the same amount of rubber deposited in each, they require slightly different durations of azimuth rotation due to the fact that there is a difference in the patterns that are followed by the ribbon in the two sectors as illustrated in Figures 1 and 2. Briefly, whereas sector D is a mirror image of sector B, the inclination of the ribbon in sector D is not a mirror image but is in the same direction as in sector B. Thus it is necessary to employ different pitch for sectors B and D, whereas the same pitch may be employed for sectors A and E, the appropriate component being brought into operation twice in each cycle.

The azimuth movement may take place during arcs varying from 30° to 180° of the circumference of the casing. In general, the minimum and maximum values should be sufficiently large to avoid as much as possible sudden starts and stops and distortion of the pattern.

It will be appreciated that similar remarks apply to the winding of a layer by the first method employing variable azimuth speed, instead of constant speed and variable duration, except that in Methods No. 1 and No. 2 the azimuth movement is continuous, not a start-stop movement, and therefore, the lateral displacement of the ribbon produced by the azimuth rotation, takes place continuously and is distributed evenly over the entire 360° in each revolution. Hence the advantages of Methods 1 and 2 over 3.

The programmer for practising Method 3, namely employing constant speed but variable duration of azimuth movement, does not need a transducer to time the duration of the azimuth rotation as a function of the azimuth speed because as long as the azimuth arc is less than 360°, i.e., from, say, 30° to 120°, it is not dependent upon variations of spin speed. This is due to the fact that there is ample time to introduce the total azimuth movement in each spin revolution, even if the spin speed changes considerably. Even though Methods 1 and 2 use such a transducer, the advantages of the Methods 1 and 2 are too basic to be judged solely on the basis of the presence of an additional transducer in a programmer. In each of the machines to be described the spin speed does remain constant but is controlled to keep pace with the speed of extrusion of the rubber strip, and the speed transducer in the programmers for methods 1 and 2 introduces a control voltage to take the variation in the spin speed into consideration. Because of the continuous control of the azimuth movement, Method 1 is preferable to Method 3; and Method 2, employing continuously variable azimuth movement, is regarded as giving a better result than either Method 1 or Method 3. Moreover, the Method 3 is hardly practicable for machines running at high speed since the period available for the azimuth motor to start, effect its movement, and stop again, may in certain circumstances be very short. Moreover, the electronic components of a programmer in Method 2 have a greater accuracy and reliability than the components of the programmers for Methods 1 and 3. This will become more apparent from the description of the respective programmers given below.

GENERAL ARRANGEMENT OF MACHINE FOR RETREADING BY METHOD 1

Before describing the details of the machine with reference to Figures 5 to 21, it may be convenient to give a general indication of its arrangement and functioning.

As already indicated, the tyre casing is mounted to rotate about a horizontal spin axis and the casing simultaneously is also rotated, or moved, in azimuth about a vertical azimuth axis.

To provide for different sizes of casing, means is provided for adjusting the position of the spin axis by moving it either towards or away from the azimuth axis.

A local extruder extrudes a ribbon of elastomeric material which is then conveyed to a stitcher. The stitcher is mounted on an arm pivoted at its lower end so that its upper end can be moved towards or away from the casing. Its upper end carries a roller under which the ribbon passes onto the casing and which is driven to rotate the casing, and also carries a number of stitching or pressure rollers to press the layers of ribbon towards the casing. The stitcher arm is acted on by springs or a hydraulic

ram to maintain the pressure with the casing. A separate electric motor is arranged to drive the azimuth shaft through a chain engaging a smooth pulley on the azimuth shaft, means being provided for tightening the chain to effect a drive and loosening it to allow the casing to be turned manually in azimuth, preparatory to the start of the process on each casing.

Once started, the complete process is entirely under automatic control. For this purpose a punched card programme unit is provided to receive the appropriate one of a number of punched cards which incorporate the requirements for a large number of standard tyre sections, and also bear written data to enable the user to effect manual adjustments, for example, of the distance of the spin axis from the azimuth axis.

Between the extruder and the stitching arm the ribbon passes round a dancer roller, the movement of which is employed to control the spin speed so as to ensure that the rate at which the ribbon is wound onto the casing is equal to the rate at which the ribbon is extruded. Moreover, a transducer is incorporated in the stitcher head to respond to the thickness of the ribbon immediately before it is applied to the casing and to effect appropriate adjustment to the azimuth movement in accordance with the thickness of the ribbon.

AZIMUTH MOVEMENT CONTROL, GENERAL BASIS

Once the operation is started, with the spinning motor rotating the casing and the ribbon adhering to it, the spinning movement continues uninterrupted throughout the operation, the spin speed being controlled merely to keep pace with the rate of extrusion of ribbon. The whole of the variation of thickness of material deposited is effected by automatic control of the azimuth movement.

The main parts of the automatic control mehanism comprise an azimuth speed control for determining the speed of azimuth movement, a stepping switch, and a punched or embossed card programme unit.

The action of the azimuth speed control depends on variation of speed of the azimuth driving motor which is a d.c. shunt wound motor having its armatures supplied through a silicon controlled rectifier from a rectified unsmoothed supply. The controlled rectifier is controlled by a magnetic amplifier which receives a controlling signal from a spin tachometer, through a ribbon thickness transducer and a network of adjustable resistors which are brought into circuit successively in succeeding sectors of the tyre casing by the stepping switch. The signal is balanced against that from an azimuth shaft tachometer so as to give a feedback effect.

The adjustable resistors are manually preset for each type of tyre by means of knobs provided with pointers on the programme unit. The programme unit has a large number of templates or punched cards, one for each type of tyre, each template having holes to fit over the knobs and their pointers, so that a template can only be placed in position when the knobs have been adjusted to the correct positions for that particular type of tyre. The template also carries a scale on which are punched holes or projections at positions depending upon the type of tyre. The template is scanned by a micro-switch unit which is moved along in accordance with the azimuth rotation of the casing, so that for any particular type of tyre the micro-switch unit will be actuated at predetermined azimuth positions to advance the stepping switch.

The stepping switch comprises seven cams each actuating three contacts and arranged to be moved round step by step when a stepping relay is energised and then de-energised. Each of the sectors A to E of the casing is associated with one position of the stepping switch. In each of these positions certain contacts of the stepping switch select the appropriate one of the speed control resistors in order to determine the speed of azimuth movement in each of the sectors A to E of the casing, and hence what degree of overlap there will be between successive turns of the ribbon and hence how the thickness of elastomeric material will vary.

As described in more detail below, the stepping switch relay is capable of being energised through any one of six different stepping circuits which may be divided into three types.

A number of actions are required to be performed or initiated at a predetermined position of the casing in its spin revolution and for this purpose a group of spin switches are provided which are actuated at a predetermined position of the casing in its spin revolution.

Secondly, a number of stepping circuits include a pair of self-interrupting contacts which alternately open and close when energised. When such a stepping circuit is closed the self-interrupting contacts alternately open it and close it again so as to cause the stepping switch to advance rapidly step by step. Such circuits will include contacts operated by the stepping switch to cause it to stop when it has returned to its initial or home position, or when it reaches some other predetermined position. Such circuits are relied on to miss out one or more of the beauty rings and to advance the stepping switch to its home position.

Thirdly, the stepping switch relay may be energised through a stepping circuit con-

trolled by the punche[illegible]d, and this will be the normal action f[illegible]inding the main portions of the tyre. In this case the stepping switch will remain in a given position, irrespective of the number of spin revolutions executed, until a certain azimuth position has been reached, whereupon the punched hole or projection in the card will break the energising circuit of the stepping switch and cause it to advance to the next stop.

RIBBON WINDING MACHINE

Figures 5 and 6 are general views of the machine in elevation and plan respectively. The machine comprises a box-like platform 102 extending from a wall 103 of a box-like casing 101. The casing 101 houses an extruder 104 driven through a gearbox 105 by a motor 106, and also supports the programme unit and power controls with switches, fuses, compressed air piping and valves, described in more detail below.

The extruder is provided with a screw 107 having a central bore 108 communicating through a stationary pipe 109 and coupling 110 with a source of cooling water. The water flows through the pipe 109 to the tip of the screw and thence returns through an annular space between the pipe 109 and the bore 108. The extruder has a jacket 111 by which the temperature of the material being extruded may be controlled. Water enters the jacket 111 through a flexible hose 114 connected to an incoming cooling water pipe 115 and leaves through a hose 116 leading to an outgoing pipe 117. A thermostatic valve 118 is included in the pipe 114 to control the rate of cooling by regulating the amount of cooling water flowing through the circuit in accordance with the jacket temperature. A solenoid-operated valve V_1 is also connected in series with the hose 115 and is automatically opened when the machine is started and closed when the machine is stopped.

The extruder terminates in a die member 119 provided with heaters 120 controlled by thermostats.

Accordingly, the temperature of the extruder and the material being extruded is maintained within reasonably close limits to avoid over-heating and to maintain the temperature of the extruded ribbon in the range of 150°F to 250°F. Experience has shown that the smoothness of the extruded ribbon is quite sensitive to the viscosity, which can be controlled by regulating the temperature of the extruder to a value at which the best smoothness is produced in the extruded ribbon.

The box-like casing 101 is also provided with a hopper 121 for feeding the elastomer into the extruder with the aid of rollers 122 and 123 from a container 124.

The incoming ribbon 125 is produced by mixing the materials in a[illegible]bury mixer and then transferring the m[illegible]onto sheeting machines; the elastomer sheets are cut into continuous ribbons 126 which are between 3" and 5" wide and from $\frac{1}{4}$" to $\frac{1}{2}$" thick, and then such ribbon is fed into the extruder at the rate controlled by the extruder. In order to prevent adhesion between convolute turns of the continuous ribbons 126 in the box 124, the ribbon 125 is dusted and covered with such anti-adhesive agents as zinc stearate slurry, soap solution, or dusting talc.

The casing 101 also supports a control panel 127 which will be described below in connection with the programme control unit.

From the extruder the ribbon 130 passes over an idler roller 131 mounted on a fixed arm 132 and thence under a dancer roller 133 mounted on a pivoted arm 134 carried by a shaft 135 controlling a potentiometer 136. As described below the potentiometer serves to vary the speed at which the ribbon is wound onto the casing so as to keep pace with the rate of extrusion, and in addition if the ribbon should break, the downward movement of the dancer roller arm stops the whole machine.

AZIMUTH RADIUS MECHANISM

A tyre casing 150 requiring to be retreaded is mounted on an expandable wheel 151 which may be as described in U.S. Patent Specification No. 2,960,130. The wheel 151 is mounted on a horizontal spin axle 152 supported at the upper end of an arm 153 having its lower end pivoted at 154 on the horizontal leg portion 155 of an L-shaped azimuth arm 156 carried by a vertical azimuth shaft 157.

It will be appreciated that as the tyre casing is rotated about its spin axle 152 it will be turned in azimuth about the axis of the azimuth shaft 157, and it is desirable that the latter axis should pass as closely as possible through the centre of the tyre section indicated at O in Figure 1, or at least of that part of it on which the elastomeric material is to be wound, namely the sectors A, B, C, D and E. The pivoting of the arm 153 at its lower end 154 enables the spin axle 152 to be adjusted towards and away from the azimuth shaft 157 so as to enable this condition to be satisfied for tyres of different sizes.

To assist in carrying out this adjustment, a handwheel unit shown in Figure 7 is provided. The pivoted arm 153 carries a hub 160 forming a bearing for a shaft 161 in which are mounted a handwheel 162 and a pinion 163 co-operating with a stationary rack 164 secured to an inclined upper portion 165 of the L-shaped azimuth arm 156. As shown in Figure 7, the shaft 161 also carries a larger pinion 166 engag-

ing a locking rack 167. The shaft 161 can be moved longitudinally against the action of a spring 168 so as to disengage the pinion 166 from the locking rack 167 whilst the pinion 163 remains engaged with the rack 164. The handwheel can then be turned to adjust the pivoted arm 153 rotatively to the L-shaped azimuth arm 156 and when it is released the spring 168 will return the shaft to the position shown in Figure 7 in which the pinion 166 meshing with the locking rack 167 locks the shaft 161 and hence clamps the pivoted arm 153.

In order to ascertain the correct adjustment, means is provided for measuring the outside diameter of the buffed tyre casing 150. For this purpose an arm 169 is mounted to slide up and down the pivoted arm 153 on a slidable sleeve 170 counterbalanced by a counterweight 171 connected to it by a cable 172 passing over a pulley 173. Also mounted on the sleeve 170 is a plate 174 carrying a transparent indicator 175 having crossed hair lines 176. The sloping portion 165 of the azimuth arm 156 carries a plate 177 bearing a scale 178 consisting of two sets of intersecting lines. One set indicate the outside diameter of the casing as measured by the arm 169 whilst the other set indicate the desired radius of the casing. The latter figure will be printed on the programme card appropriate to the particular type of tyre, from which the user can read it off. For example, the card 180 shown in Figure 12 indicates at 181 that a 670 × 15 casing, which is to be moulded in a special 670 × 15 custom-designed mould No. 463F (these mould numbers are private serial numbers of various mould manufacturers such as Lodi of California) should have an azimuth radius of 3½". The number of the mould, which produces a desired tread, is also specified on the card at 182.

By turning the handwheel 162 to adjust the distance between the spin axle 152 and the azimuth axis 157 with the aid of the scale 178 and the information given on the programme card, the azimuth radius will be made substantially equal to the radius of a circle which best approaches the cross-sectional locus of the outer surface of the casing and more particularly of the sectors A to E of it.

STITCHER AND SPIN MOTOR ARM

The ribbon is applied to the tyre casing, and the casing is rotated about its spin axis 152 by means of a spin wheel 200 carried by an arm 201 secured at its lower end to a shaft 202 mounted in a pair of bearings 203. The upper end of the arm 201 carries a spin motor 204 connected through a gear-box 205 and shaft 206 to drive the spin wheel 200. To maintain driving pressure between the spin wheel 200 and the tyre casing, the arm 201 is provided with a downward extension 207 acted on by the piston rod 208 of a pneumatic ram 209 connected to a source of compressed air through pipes 210 and 211 and a three-way solenoid-operated valve V_2. By actuation of the solenoid-operated valve V_2 the arm 201 can be swung to the right to apply pressure between the spin wheel 200 and the tyre casing or can be retracted to the position shown in chain lines in Figure 5.

RIBBON THICKNESS TRANSDUCER

The arm 201 also carries an idler roller 220 and a ribbon thickness gauging roller 221 mounted on an arm 222 pivoted at 223 and connected to the cores 224 of a pair of transducers 225 and 226 in the form of differential transformers. The ribbon passes between the rollers 220 and 221 on its way to the spin wheel 220 so that the thickness of the ribbon determines the position of the cores 224 and hence provides two alternating current signals giving a continuous measurement of the thickness of the ribbon. One of these is employed, as described below, to modify the azimuth speed in accordance with the ribbon thickness. The other is employed to energise a voltmeter 227 mounted on the panel 127 and calibrated to read in terms of ribbon thickness. This is used in the initial adjustment of the extruder die.

STITCHER

The arm 201 also carries a stitcher 230 which is shown in greater detail in Figure 8. The stitcher comprises a hollow box-like frame 231 of the shape clearly shown in Figure 8 having a foot (not shown) pivotally carried by a pin 232 in a bracket 233 secured to a casing 234 which is mounted at the top of the arm 201 and also houses the spin motor, the transducers 225 and 226 and their rollers 220 and 221. The frame 231 can therefore rock about the pin 232 as indicated by dotted lines 235 and 236. The bracket 233 affords stop shoulders 237 and 238 to limit the swing of the frame 231 in either direction. The frame affords four breached openings 239 into which fit nine sliding stitching arms 240, five extending through the upper openings and four extending through the lower openings. Each of the stitcher arms is provided with a stitching wheel 241, some of which are serrated so as to obtain a more positive stitching of the edges of the ribbon to the surface of the casing. Each of the stitching arms is tensioned by a pneumatic actuator 242 having a piston rod 243 connected to the stitcher arm and a cylinder 244 secured to the frame 231. Tension springs can also be used.

Compressed air is introduced through a flexible hose 245 to a distributor block 246 having a number of cylindrical openings 247 in which the actuators fit and are secured

and to which the air is distributed by ducts 248. The piston rod 248 of each actuator is surrounded by a weak spring 249 tending to retract the stitching arm when the air pressure is released. Accordingly, the pressure exerted on the casing and the ribbon corresponds to a constant air pressure irrespective of the position of the stitching arms and irrespective of differences in the extent to which they project, so that uniform stitching pressure is achieved. The pneumatic stitcher may be connected to a source of compressed air through a pipe 250 shown in Figure 6 which also supplies compressed air to the expandable wheel 151 for supporting and inflating the tyre casing.

In operation sufficient air pressure is applied to the actuator 209 to cause it to exert proper stitching pressure for obtaining very positive engagement between the surface of the tyre casing and the spin wheel 200 as well as all of the stitching wheels 241 upon the newly applied ribbon. The stitching wheels being independently sprung will follow any irregularities in the surface and with the freshly extruded ribbon at a temperature between 150 and 250°F as it leaves the extruder its viscosity and tackiness are at their best and the ribbon is firmly stitched to the casing. The width of the four stitching wheels at the bottom of the stitcher, is greater than the width of the ribbon 130, and therefore, the first four bottom stitcher wheels apply pressure to a surface which is wider than the width of the ribbon. The top stitching wheels cover an even greater width and are in a staggered position with respect to the lower stitching wheels so that the full width of the ribbon is more than covered irrespective of the angular position of the stitcher and of the ribbon. The stitcher can swing through an angle indicated by the lines 235 and 236 in Figure 8 so as to be self-aligning with respect to the surface of the casing as relative movement occurs. This angle may be of the order of 60-70°.

AZIMUTH MOTOR

The azimuth shaft 157 is driven by an azimuth motor 260 and a gearbox 261 mounted by means of a bracket 262 (see Figure 9) within the box-like platform 102. The azimuth shaft is rotated only in a clockwise direction, as viewed in Figure 6, (i.e., in the direction of the arrow 263) by the azimuth motor 260 through its gearbox 261 and a chain 264 driving a smooth-faced pulley 265 mounted on the azimuth shaft 157 as shown in Figure 9. Sufficient driving tension in the chain is maintained by an arm 266 pivoted at 267 and carrying a pair of idler sprockets 268 and 269 engaging opposite sides of the chain. The arm 266 is acted upon by the plunger 270 of a pneumatic actuator 271 connected by pipes 272 and 273 to the three-way solenoid-operated valve V_2 already referred t[illegible] controlling the supply to the pneumatic actuator 209 of the stitcher arm 201. Thus when the stitcher is withdrawn from the tyre casing, the chain drive 264 will be slackened so that the tyre casing and azimuth arm may be manually moved in either direction about the azimuth axis 157. This will be required after completing the retreading of one casing and in order to adjust the next casing to the proper position for starting the operation on it. Once the operation has been started, the drive from the azimuth motor to the azimuth shaft remains engaged and the starting and stopping of azimuth movement is effected entirely by starting and stopping or varying the speed of the azimuth motor 260.

CONTROL PANEL AND CARD-SCANNING MICRO-SWITCHES

As previously referred to briefly, certain events in the programme are caused to occur automatically at certain angular positions of the azimuth arm determined by a punched or embossed programme card 180.

As shown in Figures 6 and 10 the control panel 127 on the box-like casing 101 carries various indicator lamps and press button switches referred to below, as well as six knobs 280 to 285 for operating variable resistors and switches which require to be manually set for each type of tyre. For each type of tyre the user is provided with a separate programme card 180 shaped as shown in Figure 12. This has in it apertures for six knobs and their pointers, so that the programme card can only be fitted in place when the knobs are in the appropriate positions. As shown in Figure 11 the panel 127 is also provided with a hinged cover 287 which fits over the card and with the aid of springs (not shown) holds it under proper pressure against the front plate of the panel. This pressure should be sufficiently high to resist the counter pressure exerted on the underside of the card by a pair of card scanning micro-switches 288 and 289 provided with rollers 290 and 291 to engage the under-surface of the card. The panel 127 is provided with an opening 292 to give the micro-switch rollers access to the under-surface of the card 180.

In order to be moved along the card in response to the azimuth rotation of the casing, the microswitches 288 and 289 are mounted on a carriage 293 having in it a pair of bores 294 by which it is mounted to slide on a pair of guide rods 295.

The carriage 293 is connected to the azimuth motor by means of a flexible steel cable 296 (indicated in Figures 5 and 9) passing round a pulley 297 on the azimuth shaft 157 and also passing round an idler pulley 298 and additional pulleys, which are not visible in any of the drawings. Appro-

priate means (not shown) are provided to keep the two micro-switch rollers 290 and 291 in proper pressure contact with the under-surface of the card 180.

Accordingly, the carriage 293 and its micro-switches 288 and 289 will travel linearly along the card in accordance with the angular azimuth movement of the tyre casing and azimuth arm 156.

PROGRAMME CARDS

Figure 12 shows a preferred form of card in which the six holes for knobs are arranged in a single line so as to give a long linear scale along the card.

As already mentioned, each card, which may be of aluminium or a plastics, such as polyvinyl chloride, has six knob openings 286 corresponding to the knobs 280 to 285 in Figure 10. The lower part of the card 180 is provided with scales 299 and 300 which may be calibrated in degrees from 0° to 170°C representing the position of the micro-switches 288 and 289 when the tyre and azimuth arm are in a corresponding angular position.

Figure 13 is a fragmentary view of the jaws 301 of a pair of pliers provided with a projection 302 and recess 303 for deforming the card to produce indentations 304 to 308 along the scale 299 and a single indentation 309 on the scale 300. These indentations serve to actuate the micro-switches 288 and 289 as they are moved along in accordance with the azimuth movement of the tyre casing.

STARTING AZIMUTH POSITION AND CARD CALIBRATION

The top cover of the box-like platform 102 is provided with a protractor 320 (Figures 5 and 6) whilst the azimuth arm carries a pointer 321. The protractor has a scale from 15° to 165° and the pointer 321 is arranged to indicate 90° when the axis of the spin axle 152 is at right angles to the longitudinal centre-line 322 of the machine.

The indentations of the two scales of angles 299 and 300 along the lower part of the card 180 may be punched in the proper places with the aid of these scales, and data as to the angles corresponding to the sectors A and E, B, C and D of Figure 1 for the particular matrix in question. These positions may be checked, or in some cases obtained, with the aid of the protractor 320.

It will be noted that the upper scale 299 is punched at five points 304-308 while the lower scale 300 is only punched at one point 309. The latter corresponds to the starting azimuth position and actuates the micro-switch 289 to light an indicator lamp and make the programme starting circuit when the azimuth position is correct. The former correspond to the ends of the five sectors A to E of the tread and actuate the micro-switch 288 to advance the stepping switch of the control apparatus.

Accordingly, in operation the user first sets the six knobs to the appropriate positions for the particular type of tyre. Thus the programme resistor network knob 280 and the four individual resistor knobs 282 to 285 are set to their proper positions so that the thickness of the deposited layer will fully fill the matrix by providing the appropriate thickness of elastomeric material in each of the sectors A to E of the section shown in Figure 1. On the card 180 shown in Figure 12, these sectors are indicated as "wing" for the two side wall sectors A and E, "shoulder 1" for sector B, "gauge" for sector C, and "shoulder 2" for sector D. The knob 281 controls a three-position switch determining whether one, two or three beauty rings are to be wound, and is set accordingly.

The information required for setting the knobs 280 and 282 to 285 is obtained from charts which indicate the thickness of the layers obtained in different sectors along the transverse section of the casing, with different settings of these knobs for any given radius. These charts are obtained in a purely experimental manner by calibrating four programme resistors by operating the machine at a fixed radius and different resistor settings for succeeding runs of the machine and then measuring the thicknesses of the deposited layers obtained with these runs. Such calibration runs are then repeated for different radius settings.

Thus at a given radius for a given casing, a given set of settings of the knobs 280 and 282 to 285 will always produce the same pattern of thicknesses in the respective sectors, and moreover, within certain limits the same pattern can be duplicated by using a slightly but not markedly different azimuth radius and correspondingly slightly different knob settings to compensate for the predictable change in pattern that is produced by either increasing or decreasing the radius. For example, the thickness of the layer is increased with decrease in radius and vice versa if the knob settings remain constant.

SPIN SWITCHES

It will be appreciated that a number of events are required to take place at a particular point in the spin revolution of the tyre casing, so that, for example, the ribbon may be laid in a given position for precisely one revolution or that changes of azimuth speed may begin at intervals of precisely one or more revolutions. For this purpose, as shown in Figures 14 and 15, the rotating spin shaft 152 carries a spin switch cam 330 engaging rollers 331, 332 and 333 carried respectively by switches 334, 335 and 336. As shown in perspective in Figure 15, the cam 330 is provided with three depressions 337, 338 and 339. Accord-

ingly, all three spin switches are actuated substantially simultaneously once in each revolution of the spin shaft 152 and tyre casing.

The cam has gear teeth 340 meshing with a pinion 341 driving a tachometer 342 to give an alternating signal in accordance with the spin speed, so that any variation of spin speed, for example, to agree with the speed of extrusion of the ribbon, will be reflected in the azimuth speed as described in more detail below, and will not upset the winding of the ribbon to the desired pitch and thickness.

STEPPING SWITCH

An important component in the apparatus for automatically controlling the programme is a stepping switch 350, which is shown purely diagrammatically in Figure 16, but may, in fact, be of any suitable known construction. For example, it may be of the type known as the OCS Relay described and illustrated on pages 36 to 41 of Technical Bulletin 473 of The Automatic Electric Company of Chicago, entitled "Rotary Stepping Switches." The switch comprises seven cams 1 to 7, each having three contacts A to C, of which contacts A and B are normally open and are closed by a recess in the associated cam, whilst contacts C are normally closed and are opened by a recess in the cam.

The cam stack is arranged to be rotated in steps by means of a stepping relay R6, the actual stepping movement occurring when the relay is de-energised after being energised.

The cams can be rotated through 360° in 36 steps of 10°. In the present machine seven cams are used and the cycle is repeated twice per revolution so that 18 steps are involved in each cycle.

Figure 17 is a table showing by a cross which contacts are actuated in each of these 18 positions. Thus in all the Figures 17, 24, 27, 35 and 38, a cross indicates that the corresponding contacts A and B are closed and contact C opened.

As indicated in Figure 17, the operative positions of the stepping switch comprise the 20° to 40° positions and the 100° to 120° positions devoted to the winding of beauty rings if required, and the 50°, 60°, 70°, 80° and 90° positions for winding the sectors A, B, C, D and E respectively of the tyre as shown in Figure 1.

As will be described later in connection with the circuit diagrams, the main function of the stepping switch in the 50° to 90° positions is to select the appropriate one of a number of programme resistors of the azimuth speed control to determine how fast the azimuth motor will run during each sector, and hence what degree of overlap there will be between successive turns of ribbon and hence what will [illegible]e thickness of elastomeric material at that point. This is achieved by cams 1, 2, 3 and 7 and it will be seen from Figure 17 that contact 1A is closed in the 50° and 90° positions corresponding to sectors A and E, which, as already noted, can be similarly wound, contact 2A is closed in the 60° position corresponding to sector B, contact 3A is closed in the 70° position corresponding to sector C, contact 7A is closed in the 80° position corresponding to sector D.

As will be referred to in more detail in connection with the circuit diagrams, the stepping switch can be energised through any one of a number of different circuits (actually six) which may be divided into three types. Certain of these circuits include a self-interrupting contact so that when any one of these circuits is made the self-interrupting contact will alternately interrupt it and make it, thus causing the stepping switch to advance rapidly until the circuit is otherwise broken. All these circuits will include contacts operated by the cams of the stepping switch so that when it reaches an appropriate position the energising circuit will be broken and the stepping switch will step. Secondly, there is an energising circuit which includes the spin switch 335 already described which opens and closes once during each spin revolution of the tyre casing. Hence when this circuit is closed the stepping switch will be advanced one step in each revolution of the tyre casing. This circuit is employed in particular for winding the beauty rings. Thus it will cause the stepping switch to advance one step after each beauty ring has been wound, and other contacts of the stepping switch will determine whether the switch should be immediately advanced to omit the steps during which further beauty rings would be wound or to include them. Thirdly, the stepping switch may be energised through a circuit including the microswitch 288 controlled by the punched card, so that the stepping switch will continue to be energised until the tyre casing and azimuth arm reach a certain azimuth position, irrespective of the number of spin revolutions of the tyre casing that take place before this azimuth position is reached. This circuit comes into operation for winding the sectors A, B, C, D and E during which the thickness of elastomeric material is automatically controlled by means of the azimuth speed control.

CIRCUIT OF THE CONTROL APPARATUS AND PROGRAMME UNIT

Figure 18 is a complete circuit diagram of the whole equipment, the spin motor control, azimuth speed control and azimuth and stepping relay circuits appearing as blocks 401, 402 and 403 in Figure 18 being

shown in detail in Figures 19, 20 and 21.

The supply to the complete machine is controlled by a power relay R1 which, as shown at the top of Figure 18, is connected between a pair of a.c. supply terminals 404 and 405 in series with a manually-operated starting button 406. The button 406 is shunted by a holding circuit comprising normally open contacts R1A of the relay R1 in series with a manually-operated stepping button 407, contacts 5C and 6C of the stepping switch in parallel, and contacts R2D of a programme relay R2 shunted by broken ribbon contacts 408 which open when the dancer roller is released.

It will be seen from Figure 17 that either contact 5C or contact 6C remains closed throughout the cycle except at the 0° or home position.

As described below the programme relay R2 is energised to swing the stitching arm into position to start the winding, whereupon the contents R2D open. Hence the holding circuit of the power relay R1 will remain made till the end of the cycle unless either the ribbon breaks after winding has begun, or the stop button 407 is manually pressed.

The power relay R1 also has contacts R1B connected between the supply terminal 404 and a bus terminal 409 from which a large number of circuits are energised. Thus, directly connected between the bus terminals 409 and 405 is a red indicator lamp 410, to indicate that the power is switched on, the cooling water solenoid V1, and a spin motor relay R4 controlling the circuit of the spin motor shown in Figure 19 and described more fully below. In addition, there are, connected between the bus terminals 409 and 405, an extruder barrel heater 411 in series with a thermostat 412; die heaters 120 in series with thermostats 413 already referred to, and also in series with contacts 414. An amber light 415 in series with the spin switch 334 serves to indicate when the tyre casing is in the starting position about its spin axis.

Also connected between the bus terminals 409 and 405 is a programme relay R2 in series with the spin switch 336, the kick starting contacts 416 of Figures 5 and 6 and the micro-switch 289 of the punched card unit. The last three contacts (i.e. all but the relay R2) are shunted by normally open contacts R2A of this relay to form a holding circuit. The programme relay R2, the contacts 336 and the starting contacts 416 are also shunted by a green indicator lamp 417 and indicate that the micro-switch 289 is closed and hence in position. The relay R2 also has normally open contacts R2B connected between the bus terminals 409 and 405 in series with the air valve solenoid V2. Also connected between the bus terminals 409 and 405 in series with a manually-operated toggle switch 418, is a relay R3 controlling the extruder motor. This enables the extruder to be started before the programme relay is energised by actuating the kick starting contacts 416; conversely the programmer can be operated with the extruder idle. In addition, there are connected between the bus terminals 409 and 405 an azimuth speed control circuit represented in Figure 18 by a block 402 and shown in more detail in Figure 20, and an azimuth and stepping relay circuit represented in Figure 18 by a block 403 and shown in more detail in Figure 21.

Accordingly, the energisation of all these circuits is dependent upon the operation of the power relay R1 through its contacts R1B. When these are closed the spin motor relay R4 is energised and closes its normally open contacts R4A which energise the circuit of the spin motor shown in Figure 18 as a block 401 and shown in more detail in Figure 19.

SPIN MOTOR CIRCUIT

The closing of the relay contacts R4A connects between the a.c. supply terminals 404 and 405 a full wave bridge rectifier 419. The d.c. terminals of the rectifier 419 are connected to the armature 422 of the spin motor 204 in series with a silicon controlled rectifier 420 and also to the field winding 423 of the spin motor.

The rectifier 419, also serves as a d.c. supply to the speed control circuit which controls the silicon controlled rectifier 420 and hence the spin motor speed in accordance with the dancer rollers resistor 136.

The speed control circuit comprises a uni-junction relaxation oscillator synchronised to the rectified wave impressed on it by the bridge rectifier 419. The supply to the control circuit is obtained from the positive terminal of this rectifier through a resistor 424 in series with a zener diode 425. Connected across the zener diode is a PN uni-junction transistor 426 in series with resistors 427 and 428. Also connected across the zener diode are the dancer roller rheostat 136 is series with a high value resistor 429, (which is shunted by normally closed tight ribbon contacts 430) and a capacitor 431. The junction between the dancer roller rheostat 136 and the high resistor 429 is connected to the emitter electrode of the transistor 426. Opposite ends of the resistor 428 are connected respectively to the cathode and gate electrode of the silicon controlled rectifier 420.

The operation of the speed control is as follows. The wave form of the voltage impressed between the bases of the transistor 426, due to the action of the resistor 424 and zener diode 425 on the full-wave rectified output from the bridge 419, is of the form shown at 432, namely a rectified sinusoidal

wave with its peaks clipped by the zener diode. When the positive potential to which the capacitor 431 is charged exceeds the potential of base 2 of the transistor 426, the capacitor discharges through the transistor 426 and resistor 428. At the end of each half cycle the voltage across the transistor 426 will fall to zero causing the transistor to cut off. The capacitor 431 thus begins to be charged from a discharged condition at the beginning of each half cycle so that the firing circuit is synchronized with the supply. The potential drop across the resistor 428 when the capacitor 431 discharges through it and the transistor 426, is impressed on the gate electrode of the silicon controlled rectifier 420, and when this is positive with respect to its cathode the silicon controlled rectifier will fire, so that a wave form as shown at 433 is supplied to the armature 422 of the spin motor 204. Only a controllable portion of each rectified half wave flows to the spin motor and the magnitude of this portion is controlled by the rate at which the capacitor 431 is charged through the resistor 136 of the dancer roller. The armature is also shunted by a by-pass diode 421 to allow current to continue to flow through it when the silicon controlled rectifier 420 cuts off. By suitable choice of component values the speed of the spin motor is controlled so as to drive the spin wheel at the same peripheral speed as the speed of extrusion of ribbon from the extruder.

The tight-ribbon contacts 430 are arranged to be opened by the dancer roller 133 when it is in its extreme high position, to which it will move if the extruder fails to keep pace with the spin motor even when the latter is running at its minimum controlled speed, for example if the extruder should stop extruding.

If this should occur, the opening of the contacts 430 will delay charging of the capacitor 431 almost indefinitely, and the spin motor will stop until the delivery of ribbon is restored.

This provision is in addition to the broken ribbon contacts 408 of Figure 18 which as already described, open if the ribbon should break, and serve to break the holding circuit of the power relay R1 to shut down the whole machine.

AZIMUTH SPEED CONTROL

Figure 20 is a circuit diagram of the arrangement by which the speed of the azimuth driving motor 260 is controlled in accordance with the spin speed, the ribbon thickness and the chosen programme resistance for the particular sector in question, with a feedback signal representing the actual azimuth speed.

As already indicated, the spin axle 152 drives a tachometer 342 which, as indicated diagrammatically in Figure 20, is in the form of a two-phase induction motor having one stator winding 434 connected to an a.c. supply. The other stator winding 435 will then produce a voltage of the same frequency whose amplitude is proportional to the speed of rotation of the rotor, i.e., to the spin speed. This output voltage is applied through an amplifier 436 to the primary winding 437 of the ribbon thickness transducer 225. This has opposed secondary windings 438 and a movable core 224 connected as already mentioned to the arms 222 of Figure 5, so that the ratio of its output to its input voltage will depend on the ribbon thickness. Hence the output will be a function of the spin speed and the ribbon thickness.

The output of the ribbon thickness transducer 225 is fed to an amplifier 439 whereof the output is connected to a full wave rectifier 440. A programme resistor network 441 in series with an output resistor 442 is connected across the d.c. output of this rectifier, to constitute a potential divider or potentiometer. Thus the proportion of the rectifier output voltage developed across the output resistor will depend on the value of the programme resistor network at the time in question.

The programme resistor network comprises four parallel branches each including one of the stepping switch contact pairs 1A, 2A, 3A and 7A, a variable resistor 443, 444, 445 or 446, and one of a set of ganged selector switches 451, with the portions selected by it of a resistor chain 452.

The individual variable resistors 443 to 446 are operated respectively by the knobs 282 and 285 of Figure 10, while the ganged selector switch is controlled by the knob 280 marked programme.

The resistors of the chains are chosen to give the approximate thicknesses required for the respective sectors of a number of typical types of tyre, so that the appropriate programme for such a tyre can be readily selected by merely setting the knob 280 to the appropriate position, with the resistors 443 to 446 in a predetermined, e.g. mid-scale position. A wide range of further variation can then be obtained by adjustment of the individual resistors 443 to 446 starting from such a standard or typical programme. It may be left to the user to make the connections from each contact of the selector switch 451 to the chains 452 of the resistors of the network 441, e.g., by soldering, in accordance with his particular requirements.

Hence the chosen value of resistance will be brought into circuit by the closing of the corresponding stepping switch contacts during each of the sectors A to E of the casing.

A filter circuit 447-448 and a voltage limiting zener diode 449 are connected across the output of the rectifier 440.

The voltage across the output resistor 442 in opposition to that of an azimuth speed tachometer 461 is applied to a control winding 462 of a magnetic amplifier 463 in series with an adjusting resistor 464. Hence the signal supplied to the control winding of the magnetic amplifier will be an error signal representing the difference between the actual value of the azimuth speed and the desired value represented by the voltage across the output resistor 442.

The magnetic amplifier has a pair of load windings 465 each connected between one end of a centre tapped secondary winding 466 of a supply transformer 467 and the anode of one of a pair of diodes 468. The primary winding 469 of the transformer 467 is connected to an a.c. supply whilst an output resistor 470 is connected between the centre tapping and the cathodes of the two diodes.

The magnetic amplifier also has a feedback winding 471 connected across the output resistor 470 in series with a variable resistor 472 and a bias winding 473 connected to a d.c. supply (not shown).

The output resistor 470 is connected across the trigger and cathode of a silicon controlled rectifier 474. The anode and cathode of this controlled rectifier are connected in series with the armature 475 of the azimuth motor 260 across the output of a rectifier 476 in series with contacts R5A of the relay R5. The rectifier 476 is fed from an a.c. supply. The field 478 of the motor 260 is connected across the armature and controlled rectifier whilst a surge suppressor or transient shorting circuit comprising a pair of diodes 479 is connected across the controlled rectifier.

The armature 475 is also shunted by a bypass diode 480 to allow current to continue to flow through it when the silicon controlled rectifier 474 cuts off. Thus the voltage applied to the armature will fluctuate between zero and the peak value of the supply, but the current will be smoothed to a great extent by the inductance of the armature, its mean value being controlled by the timing of the firing of the controlled rectifier.

The controlled rectifier 474 controls the speed of the azimuth motor 260 in known manner, somewhat analogous to that of the spin motor circuit shown in Figure 19. Thus briefly the average current in the motor armature depends on the moment in each half cycle at which the controlled rectifier fires, and this depends on the output of the magnetic amplifier. The latter in turn depends on the spin speed, the ribbon thickness and the chosen value of the programme resistor network for the sector being wound, as well as the actual speed of the azimuth shaft.

The second ribbon thickness transducer has its primary winding similar to the transducer 225 but has its primary winding connected to an alternating supply and its differentially connected secondary windings connected through an amplifier to a voltmeter which may be calibrated directly in terms of ribbon thickness.

AZIMUTH AND STEPPING RELAY CIRCUITS

Figure 21 shows the circuit of the azimuth motor relay and stepping relay.

For energising the azimuth motor relay R5 and stepping relay R6, a full-wave rectifier 501 is connected between the a.c. bus terminals 409 and 405 and gives a d.c. output (of perhaps 90 volts) between d.c. supply terminals 502 and 503.

The azimuth motor relay R5 is connected across these d.c. supply terminals in series with a limit switch 504, a parallel group of contacts 1B, 2B, 3B and 7B of the stepping switch and contact 4B of the stepping switch.

The stepping relay R6 is also connected between the 90 volt d.c. terminals 502 and 503 through any one of six branch circuits. These, as indicated in Figure 21 from the top downwards, are as follows.

First there are normally closed contacts 505 of the manual reset push switch 506, then (in series) contacts 1C, 2C, 3C and 7C of the stepping switch, normally open contacts R2C of the programme relay R2 and finally a normally open contact 507 of the spin switch 335 followed by the contacts 4B of the stepping switch. It will be noted that this circuit is opened by the stepping switch 335 once in each spin revolution so that when it is otherwise completed it will move the stepping switch one step for each spin revolution. The contacts 505 of the manual reset switch 506 are also connected through normally open contacts R2E of the relay R2 to the conductor 508 and thence through the contacts 4B to the positive supply terminal 502. This circuit will only be broken when the tyre casing reaches a particular azimuth position depending upon the punching of the card and hence the stepping switch may remain in a given position corresponding to one of the sectors A to E of the casing for any number of spin revolutions.

The other circuits for energising the stepping relay R6 are connected through self-interrupting contacts 509. These connect the stepping relay to a conductor 510. The conductor 510 is connected through normally open contacts 511 of the manual reset push switch 506 to the conductor 508 and thence through the contacts 4B to the positive supply terminal 502. The conductor 510 is also connected by the three-way beauty ring switch 512 and either or both of the contacts 5A and 6A of the stepping switch to the conductor 508 and thence through the

contacts 4B to the positive supply terminal 502.

Finally, the conductor 510 is connected through the stepping switch contacts 6B and 4C in series direct to the positive supply terminal 502.

It will be appreciated that when any of the circuits to the stepping relay is completed through the self-interrupting contacts 509 the circuit will be alternately opened and closed so as to produce a series of steps of the stepping switch in rapid succession. Thus, for example, if the manual reset switch 506 is pressed to open the contacts 505 and close the contacts 511 the stepping relay will continue to step rapidly round until the contacts 4B open.

The stepping switch relay R6 is shunted by an arc suppressing diode 513 to prevent false operation by transients.

GENERAL OPERATION

The power relay R1 is first energised by pressing the starting button 406. Contacts R1A close its holding circuit since the programme relay R2 is not yet energised and hence its normally closed contacts R2D are closed. Closing of the power relay contacts R1B lights the red lamp 410 to indicate that the power is switched on.

Closing of the contacts R1A, energising the terminals 409 and 405, also energises the rectifier 501 and supplies current to the stepping relay R6 (Figure 21) through the stepping switch contacts 6B and 4C which, as shown in Figure 17, are at this time closed. This current flows through the self-interrupting contacts 509 and causes the stepping switch to make a step from the home position to the 10° position at which contacts 6B and 4C both open.

Movement of the stepping switch from the home position to the 10° position also closes contacts 5C and 6C so as to make a holding circuit for the relay R1 through its contacts R1A (Figure 18) and keep the power relay R1 energised after the programme relay R2 is energised and opens the contacts R2D. It will be noted from Figure 17 that throughout the rest of the cycle either contact 5C or contact 6C remains closed until the 180° or home position is again reached at the end of the cycle, so that the holding circuit of the power relay R1 remains closed throughout the remainder of the cycle, unless it is manually broken by the stepping button 407, or by the broken tape contacts 408 at a time when the relay contacts R2D are also open.

The tyre casing 150 is then moved manually to the proper azimuth and spin starting positions, closing the card controlled micro-switch 289 and the spin switch 334 and lighting the green lamp 417 and amber lamp 415.

Energisation of the bus terminal 409 energises the spin motor relay R4 closing the circuit of the spin motor which accordingly begins to rotate.

The user then closes the switches 414 to allow the die and jacket of the extruder to warm up, after which the manual toggle switch 418 is closed to start the extruder. The raw stock is fed into the extruder and for some time the ribbon is deposited on the floor of the machine until the extruder has been warmed up to the proper extent and is producing a smooth even ribbon. The ribbon is then threaded over the idler roller 131, under the dancer roller 133, between the ribbon thickness gauging rollers 220 and 221, and under the spin wheel 200 and is tacked on to the side wall of the casing 150.

As soon as the ribbon is threaded into the machine the dancer roller will be raised and will close the broken ribbon switch 408. Accordingly, when the programme relay R2 is energised and the generally closed contacts R2D open, this does not interfere with the holding circuit of the relay R1.

Thereupon the user actuates the starting kick switch 416 to energise the programme relay R2, thereby closing the contacts R2B to energise the air valve solenoid V2 to swing the stitcher and spin wheel arm 201 towards and against the casing 150 as already described. The air valve also applies tension to the chain connecting the azimuth motor to the azimuth shaft but at this time the azimuth motor is not energised. The spin wheel 200 starts the rotation of the tyre casing 150 about the spin axle 152 so as to wind the ribbon onto the casing at a speed controlled by the dancer roller to keep pace with the rate of extrusion.

As the stitcher engages the ribbon and stitches it to the side wall of the tyre casing the operator has the free end of the ribbon in his hand and tears it off and returns it to the hopper of the extruder.

The closing of contacts R2A makes a holding circuit to keep the relay R2 energised when the kick-switch 416, the spin contacts 336 and the micro-switch 289 open.

It will be noted that the starting kick-switch 416 is in series with the spin contacts 336 and the card controlled micro-switch 289 so that the air valve solenoid V2 can only be energised when the tyre casing is in the correct spin and azimuth positions. For the particular type of tyre the punched card 180 will bear a punching at a position corresponding to the desired azimuth starting position, and the closing of the micro-switch 289 when the tyre casing has been brought to the corresponding position not only lights the green lamp 417 to indicate this fact to the user, but also closes a gap in the circuit of the kick-switch 416. Since the tightening of the chain is also controlled by the air valve solenoid V2 the tyre casing remains free to be turned manually about the azimuth

axis unt[illegible] micro-switch 289 is closed, the green li[illegible]17 is illuminated and the user has actuated the kick switch 416 to energise the air valve solenoid V2.

Immediately the spin wheel 200 engages the casing 150 all three spin switches 334 to 336 are transferred to their second set of contacts. The spin switch 335 moves to its contacts 514 opening the circuit of the stepping relay R6 and causing the stepping switch to move from the 10° position to the 20° position.

At this time all four contacts 1B, 2B, 3B and 7B of the stepping switch are open so that the azimuth motor relay R5 cannot be energised and the winding of the ribbon therefore proceeds on a surface of revolution or at zero pitch to wind one or more beauty rings on the side wall.

The arrangement provides for the winding of one, two or three beauty rings at each side of the tyre, the number being determined by the position of the beauty ring switch 512 (Figure 21) controlled by the knob 281 (Figures 5 and 10).

In the position shown in Figure 21 the beauty ring switch 512 connects the conductor 510 to the conductor 508 through both contacts 5A and 6A so that if either of these contacts is closed the stepping switch relay R6 will be energised through the self-interrupting contacts 509. At the end of the revolution corresponding to the first beauty ring the spin switch 335 will move to the contact 507 and back again so that the stepping switch steps on to the 30° position. It will be seen from Figure 17 that in this position contacts 5A are closed, hence the stepping relay is energised through the self-interrupting contacts and immediately steps on to the 40° position. In this position contacts 6A are closed, so that the stepping relay is again energised through the self-interrupting contacts and immediately moves on to the 50° position. As indicated in Figure 17 this is the position for the winding of sector A of the tyre.

If, on the other hand, the beauty ring switch is disconnected from contact 5A then in the 30° position the situation will be the same as in the 20° position, namely that the stepping switch will not be de-energised again until the tyre casing has completed a further spin revolution and wound a second beauty ring, whereupon a step will be produced by the to-and-fro movement of the spin switch 335. Similarly if the beauty ring switch 512 is disconnected from both contacts 5A and 6A the step from the 30° position to the 40° position and the step from the 40° position to the 50° position will be delayed until the end of a spin revolution so that three beauty rings will be wound.

It may be desirable to explain the reason for providin[illegible]tacts R2C in series with the contact 5[illegible] the spin switch 335 in the circuit for energising the stepping relay R6. When the tyre casing 150 is manually turned to place it in the proper spin position it may be subjected to a to-and-fro movement which will repeatedly change over the spin contacts 335. If the contacts R2C were closed at this time the stepping switch would be stepped forward a number of steps.

At the conclusion of the winding of the beauty rings, whether one, two or three rings are wound, the stepping switch moves on, as already indicated, to the 50° position. As shown in Figure 17 this closes contacts 1B and energises the azimuth motor relay R5. In addition, contacts 1A are closed, so that the resistor 443 is connected in the programme resistor network shown in Figure 20. Accordingly, the azimuth motor runs at a speed depending upon the value of the resistor 443. For sector A, as shown in Figures 1 to 3, this speed is a maximum, so that a minimum overlap and a minimum thickness of tread material will occur in sector A.

Contacts 1C of the stepping switch in series with the contact 507 of the spin switch 335 are at this time open, so that the stepping switch is not advanced once per spin revolution by the spin switch 335 as it was during the winding of the beauty rings.

Accordingly, the stepping switch remains in the 50° position irrespective of the number of spin revolutions required for the winding of sector A. The next step, to the 60° position for winding sector B, occurs when the casing and azimuth arm reach the appropriate azimuth position and the card scanning micro-switch 288 is actuated by the perforation to close and then open again. Thus the duration of the winding of sector A is determined by the position of the indentation 304 on the card 180.

The winding of sector B, in the 60° position of the stepping switch, is closely analagous to that of sector A. The contacts 2B of the stepping switch are closed instead of the contacts 1B to close the circuit of the azimuth motor relay, but this makes no difference as the contacts 1B and 2B are in parallel. The contacts 2A in the azimuth speed control circuit are closed instead of the contacts 1A so as to bring in the resistor 444 instead of the resistor 443. This greatly reduces the speed of azimuth movement thereby increasing the overlap and increasing the thickness of elastomeric material to form the shoulder sector B. Contacts 2C open instead of contacts 1C to prevent the stepping switch being advanced by the spin contacts 335, but this makes no difference as the contacts in question are in series. In other respects the winding of sector B closely follows that of sector A and is terminated when

the card scanning micro-switch 288 is again closed and opened at the appropriate azimuth position and advances the stepping switch to the 70° position for winding sector C. The winding of sectors C, D and E is identical to that of sectors A and B, except, of course, that in sector E the contacts 1A are again closed as in sector A, to make use of the same timing resistor 443.

The 100°, 110° and 120° positions of the stepping switch are a precise repetition of the 20°, 30° and 40° positions and serve in precisely the same way for the winding of one, two or three beauty rings. As in the case of 20°, 30° and 40° positions, contacts 1C, 2C, 3C, and 7C are all closed, so that the spin switch 335 produces a step at the end of each spin revolution. In the 110° position contacts 5A are closed so that the 3rd, or the 2nd and 3rd beauty rings may be omitted, depending upon the position of the beauty ring switch 512, by closing the circuit of the stepping relay through the self-interrupting contacts 509. If the beauty ring selector switch 512 is left undisturbed, the same number of beauty rings will be wound on both side walls, but if desired, the switch may be manually shifted during the winding of sectors A to E so as to produce an unequal number of beauty rings on the two side walls.

When the second set of beauty rings has been wound, the stepping switch is advanced to the 130° position. This closes contacts 4C as shown in Figure 17 and as contacts 6B are already closed the stepping relay is energised direct from the supply terminal 502 through the self-interrupting contacts 509, so as to be rapidly advanced through the 140° to 170° positions to the home position. As indicated in Figure 17, this is the only position in which both contacts 5C and 6C are open at the same time, and as indicated at the top of Figure 18, this opens the holding circuit of the power relay R1, which accordingly, releases the switches off the whole machine. Accordingly, all the relays become de-energised, including the air valve relay V2, so that the compressed air connections to the actuators 209 and 271 are reversed so as to withdraw the stitcher arm from the casing. The extruder motor 106 is also stopped and the whole machine comes to rest.

MACHINE FOR MAKING NEW TYRES BY METHOD 1

Figure 22 is a perspective view of a machine suitable for depositing a variable thickness layer on a casing of a new tyre in the course of its original manufacture. The casing 541 is mounted on a collapsible drum 542 of known construction, which is rotatably mounted on an axle 543 held by a column 544. It is rotated around the axle 543 by means of the spin motor 204 as in the earlier figures. In Figures 5 and 6, the azimuth motor 260 rotates the casing 150 about the vertical azimuth axis 157, because the casing 150 has the shape of a toroid. In Figure 22 the casing has the shape of a hollow right cylinder, and the feeding movement, which will still be referred to for convenience as azimuth movement is a longitudinal shift along the spin axle 543 as indicated by an arrow 545. To obtain such linear "azimuth" shift the drum 542 and its carriage 546 are provided with four wheels 547 (only two are visible) which run on two rails 548, which are parallel to the spin axle 543. Accordingly, the drum 542 and its entire carriage 546 are shifted along the rails 548 by means of a chain 549, the ends of which are connected to the carriage. The chain is driven by a motor 550 which corresponds to the azimuth motor 260 in Figures 5 and 6, and it is this motor that produces the linear "azimuth" movement of the drum 542 and its carriage 546. The extruder 104 corresponds to the similarly numbered extruder in Figures 5 and 6, and the ribbon 130, produced by the extruder, is wound on the casing 541 in the same manner as illustrated in Figures 2 and 3 as the drum and its carriage are shifted in the direction of the arrow 545. Upon the completion of the winding cycle, the azimuth motor 550 is automatically disconnected in the same manner as described previously, de-energising additionally, in this case, an electrical clutch 551, which corresponds in its function to the relay-operated three-way valve V2 and cylinder 271 in Figures 5 and 9, whereupon the carriage 546 is manually returned to its original position. The azimuth motor 550 is mounted in a cabinet 552, and this cabinet includes the programmer identical to that illustrated in Figures 18 to 21. As in the earlier figures, a suitably calibrated card 180, such as that illustrated in Figure 12 is used for controlling the machine. The card scanning mechanism is similar to that illustrated in Figures 5 and 11. It is connected to a pulley 553 driven by the azimuth motor 550 when the azimuth motor is connected by means of the electrical clutch 551 to the pulley gear drive 554.

The operation of the machine illustrated in Figure 22 is otherwise similar to the operation of the machine illustrated in Figures 5 to 22 with the differences pointed out below in connection with the description of Figures 23 and 24 which correspond to Figures 2 and 17 for the retreading machine.

The pattern produced on the new, or "green" tyre casing 561 is illustrated in Figure 23 as a cross-section of the upper portion of the casing 541 and drum 542 of Figure 22 and a variable thickness layer 562. The elastomeric layer 562 includes two beauty rings 563, as has the retread of

Figure 2[illegible]he two sidewall portions 564 of the new [illegible]e extend not only beyond the beauty rings but beyond the bead portions 565 to provide a layer of elastomeric material which generally is wrapped around the beads after the outer portions of the drum 542 are collapsed (for simplicity, the drum 542 is illustrated as a solid piece; collapsible drums are well known in the tyre art) so as to permit concave rollers (not shown) to wrap the over-hanging layers 564 around their respective beads 565.

Upon completion of this operation, the drum is collapsed completely and the casing is ready for compression moulding.

As in Figures 1 and 2 the casing is sub-divided into five sectors A-E, which were described in conjunction with the description of similar sectors at the introductory part of the specification and are also described below in connection with the description of Figures 23 and 24.

Figure 22 also shows a portion of the conveyor 555 which feeds the large size elastomeric ribbon 125 from a container 124 into the extruder 104. The ribbon 125, as mentioned previously, may be from 2" to 4" wide and from ¼" to 1" thick, the actual size depending on the size of the casing 541 and the size of the extruder 104 being used. Heavy duty tyres require a large amount of rubber and this, in turn, requires increase of the dimensions of the ribbon 130 from a more common 1" × 0.1" cross-section for conventional passenger cars and truck tyres to a larger size ribbon 130 for "off-the-road" tyres, i.e., tyres for bulldozers, graders, earth-movers, and the like. The ribbon 130 then may be as large as 4"- 6" wide and from 1/8" to 1/2" thick, which requires a larger size ribbon 125 for feeding an extruder which is many times larger than that shown in Figure 22.

PROGRAMMER FOR NEW TYRES

The programmer for the new tyres is in essence identical to the one described earlier. The minor changes are described below.

Figure 24 is the table indicating the degrees and the positions of the notches or the low points on the cams for producing the winding of Figure 23.

The only difference between Figures 2 and 17 and Figures 23 and 24 is that in this case the beauty rings 563 are now positioned within their respective sectors A and E, while in Figures 1, 2 and 3 the beauty rings F and G are positioned at the outer edges of their respective sectors A and E. To achieve this change in the positions of the two beauty rings, the cams of the stepping switch are modified to produce a corresponding change in the operation of the programmer. Thus, the first portion A_1 of sector A now corresponds to the 30° position, the rings correspond to the 40°, 50° and 60° positions, and the rem[illegible]g portion A_2 of sector A corresponds to [illegible]e 70° position.

In Figures 24 sectors B, C and D, which are identical to those in Figure 17 are now located on the 80°, 90° and 100° positions respectively. The changes in sector E correspond to the changes in Sector A. It is now sub-divided into sectors E_1, and E_2, with sector E_1 on the 110° position and sector E_2 on the 150° position. The last turn 564 is completed when the stepping switch is in the 160° position.

In view of the earlier very detailed description of the programmer and of the stepping switch in connection with Figure 17, there is no need for detailed description of the operation of the programmer when the seven cams of the switch are changed in the manner indicated in Figure 24.

PROGRAMMER FOR DEPOSITING TWO LAYERS

There may be occasions in which the width of the ribbon may not be sufficiently wide for the desired thickness of tread, or it may be necessary to deposit elastomers of two different compositions. As mentioned previously, the width of the ribbon can be made wider and thicker for larger size tyres. Extrusion of a ribbon having large dimensions, such as 4"- 6" wide and 1/4" to 1/2" thick, requires a large extruder and a large horsepower motor which may be in the order of 40-50 HP. Heavy equipment of this type is costly and can be afforded only by specialty shops.

It is possible to deposit a reasonably thick layer of elastomer with a narrower and thinner ribbon and lighter equipment, which is less costly, by depositing two variable thickness layers 571 and 572 one on top of the other, as indicated in Figure 25.

Figure 27 illustrates the corresponding programming of the stepping switch, and Figure 28 illustrates that portion of the circuit diagram of Figure 21 which requires the addition of a cam No. 8 and of a pair of ganged switches 573 and 574 for either including or excluding cams No. 1 and No. 8 in the circuit of the stepping switch relay R6 and self-interrupting switch 509.

Figure 28 indicates that, when the ganged switches 573 and 574 are on their upper contacts 575 and 576, the programmer is identical to the one disclosed in Figure 21 since cam No. 8 is eliminated altogether. Therefore, the machine winds the first layer 571 on the carcass 561 in the manner described earlier in connection with Figures 23 and 24. To achieve this programme the programmer card 581 illustrated in Figure 29 is used. This has one indentation 582 at a zero reading on a lower scale 583, and the remaining nine indentations 584-592 on an upper scale 593. The two scales 583 and 593 are two linear scales which correspond respectively

to a part and the wh[illegible] the linear travel of the drum 542 in Fig[illegible]2. After the completion of the first layer 571 the machine is stopped automatically by the programmer, the card 581 is replaced by a second card 594 shown in Figure 30, and the machine is then manually returned to a new starting position indicated by an indentation 595 on a lower scale 596 on this card, which also has indentations 597, 598 and 599 on a scale 600. Before depositing the second layer 572 on the carcass, the settings of the variable resistors 444 to 446 and of the resistive network 450 are adjusted so as to produce the desired thickness of the second layer 572, and thus the ultimate combined thickness of the two layers 571 and 572, assuming, as is usually the case, that the thickness of the two layers 571 and 572 is different.

It is to be noted that only sectors B, C and D are used for depositing the second layer 572 since in the illustrated example the sidewall portions of the layer can be produced during the first winding cycle when the layer 571 is deposited on the carcass 561.

It is also possible to use a card of the type illustrated in Figure 30 for "recapping" tyres. In recapping, the desired pattern is that illustrated in Figure 26. In this case only three sectors, B, C and D are used for depositing the desired layer 601 which does not extend beyond the crown of the carcass.

In all the programmers described above, the cards used for controlling the programmer serve in a sense, for subdividing the casing electrically, into sectors by generating an electrical signal at the point of transition from one sector to the next sector. The total width of the layer deposited on the casing, therefore, is also indicated on such a card, one edge of the layer being indicated by the first indentation on the lower scale, and another edge being indicated by the last indentation on the upper scale. The stepping switch is then used for introducing different resistors into the circuit of the magnetic amplifier for each sector for changing the speed of the azimuth motor on passing from one sector to another. Even though the above system uses a limited number of sectors, five sectors in all, it, nevertheless, produces smooth, desired transitions, or variations in the thickness of the deposited layer, by depositing different thicknesses in the three basic sectors, namely, the side wall, the shoulder and the crown sectors. The thickness of the layer in the two side wall sectors is the same and it is also the same in the two shoulder sectors.

A VARIABLE AMPLITUDE CAM—METHOD 2

It is possible to obtain even better and smoother transitions, or variations, in the thickness of the deposited layer and greater accuracy in obtaining the desired thickness of the elastomeric layer to b[illegible]osited on a casing by replacing the ca[illegible]th a cam of the type disclosed in Figure 31 which is a linear cam 620. The effective length 621 of this cam, along the X axis, is then made to represent the axial width of the elastomeric layer to be deposited on the casing, and the variation in the height "*h*" of the cam, along the Y axis, is made to represent the desired thickness of the layer. This variable height "*h*" of the cam is then scanned in synchronism with the azimuth movement of the casing by means of a transducer 622, and the signal produced by the transducer is used in the programmer for contributing its share in controlling the final signal that is used for controlling the current flowing through the armature of the azimuth motor.

Thus the cam 620 has a straight edge 623 at the bottom and a variable height "*h*" edge 624 along the top. For starting and terminating the winding cycle the lower edge 623 is provided with two notches 625 and 626 which are used for actuating a scanning switch 627 by closing contacts 628 and 629 when a scanning wheel 630 mounted on a scanning arm 631 of the switch, is in the notch 625 or 626. The contacts 628 and 629 remain open when the scanning wheel 630 is between the notches 625 and 626. The variable amplitude edge 624 of the cam 620 is scanned by means of the transducer 622 provided with a scanning wheel 632 and a scanning arm 633, which shift a magnetic plunger, or core 634 of a differential transformer (shown in Figure 33, described below) of the transducer 622. A dotted line 636 diagrammatically indicates that the switch 627 and transducer 622 are mechanically mounted on a slidable frame, which is moved along the X axis, or along the cam 620, in the same manner as the carriage 293 in Figure 11, as indicated by an arrow 637.

The cam, therefore, is scanned in synchronism with the azimuth rotation or azimuth movement of the casing, in the same manner as the card 180 of Figure 12 and cards 581 and 594 of Figures 29 and 30.

Although the illustrated cam 620 is a linear cam, it is also possible to use an arcuate cam and to scan it by means of a radius arm connected directly to the azimuth shaft 157.

PROGRAMMER FOR METHOD 2; WITHOUT BEAUTY RINGS

A circuit diagram of the programmer using the variable amplitude cam is illustrated in Figures 32 and 33. This diagram is for a programmer which deposits a variable thickness layer, either on a new or a used casing, without any beauty rings. A programmer, which includes the beauty rings, is illustrated in Figures 36 and 37 and will be described later.

As will be described later in connection

with Figure 34, the stepping switch of this programmer has only three cams and only four operative positions including the home position. Hence the circuit diagram of Figure 32 only includes stepping switch contacts 1A to 3C.

Referring to Figure 32, alternating current is supplied to the programmer by supply terminals 404 and 405. The power relay R1 is connected across the supply in series with a power relay actuating push button 406, and has a holding circuit including an "off" push button 407 and relay holding contacts R1A. The power relay also has contacts R1B to energise a terminal 409 to supply the remainder of the programmer.

The extruder has two relays, a heavy duty power relay R3 which connects the three phase power to the extruder motor, and a pilot relay R7 which, inter alia, controls the power relay R3. The pilot relay R7 is connected across the terminals 409 and 405 in series with an extruder starting push button 641, which is shunted by a holding circuit comprising relay holding contacts R7B in series with stepping switch contacts 2A and 3C in parallel.

The power relay R3 is connected in parallel with the valve relay V_1 across the terminals 409 and 405 in series with contacts R7D of the pilot relay and a manually controlled switch 642.

A programme starting relay R2 is connected across the terminals 409 and 405 in series with a spin switch 334, azimuth starting contacts 628, a programme starting push button 644 and relay contacts R7A of the pilot relay R7.

Hence when the pilot relay has been energised, the extruder can be operated without starting the programme, by closing the switch 642 to warm up the extruder and obtain properly shaped and extruded ribbon suitable for winding.

The indicating lamps are similar to those of Figure 18. Thus a red lamp 410 is connected directly across the terminals 409 and 405, a green lamp 417 is connected across them in series with the spin switch 334, and an amber lamp 415 is connected across them in series with the spin switch and the azimuth starting contacts 628.

Since the programmer starting relay R2 is connected in series with the spin switch 334 and the azimuth starting switch 628, the programmer can be started only when the spin switch 334 is closed, i.e. when the tyre casing 150 and the wheel 151 are in proper angular position which has been called previously, "the proper starting spin position", indicated by the green light, and when the azimuth starting switch 628 is closed, i.e., when the wheel supporting brackets 153, 156, 155 and the azimuth shaft 157 are also in the proper starting azimuth position, which is indicated on the protractor 320, and is also indicated by the amber light 415. With the switches 334 and 628 closed and the programme starting switch 644 momentarily depressed by the operator, the relay R2 becomes energised and locks itself over the holding contacts R2A and R7A. This places the programmer in operation.

When the pilot relay R7 is energised, in addition to closing its contacts R7A, R7B and R7D, as already referred to, it also closes contacts R7C which energise the rectifier 501 supplying the circuits of the azimuth motor relay R5 and stepping switch relay R6, shown in Figure 34, and the circuit of the spin motor control which is the same as that shown in Figure 19. As described below in connection with Figure 34, the contacts R2C, 3A and 509 are now closed and hence the relay R6 is energised and steps the stepping switch from the home position to the 10° position, at which time contacts 2A and 3C become closed, thus closing the locking circuit for the relay R7. Contacts R7D are also closed, and, therefore, relays R3 and V1 can be either started or stopped by manually operating the switch 642, thus either starting or stopping the operation of the extruder prior to the actuation or energisation of the remaining portion of the programmer, which is accomplished by closing the programme starting push button 644 to energise the programme starting relay R2.

The programme starting relay R2, in addition to holding contacts R2A, has contacts R2B connected across the supply terminals 409 and 405 in series with the valve relay V2 which, as in the first embodiment of Figure 18, actuates the air valve which supplies compressed air to the actuators 209 and 271 to swing the stitching arm into its operative position and clutch the azimuth motor to its drive.

Referring now more in detail to Figure 35, cam No. 1 has only one notch in the 20° position, cam No. 2 has one notch, which includes the 10°, 20° and 30° positions, and cam No. 3 has notches at the 0° and 40°. The first home position is the 0° position, and the second home position is the 40° position. The cycle of the stepping switch is completed every 40°, and it is possible to accommodate nine cycles around the 360° extent of the cams.

As shown in Figure 34, the relays R5 and R6 are connected to the rectifier 501 through various contacts. The circuit of the azimuth motor relay R5 includes contacts 1B and 2B in series. As indicated in Figure 35, contacts 1B are closed only in the 20° position of the stepping switch, when contacts 2B are also closed so that the azimuth motor and its relay R5 are energised only during the 20° position of the switch.

Also, relay R6 becomes energised only

after the first complete 360° ribbon turn has been wound on the casing, at which time the spin switch 335, which is in series with the fourth circuit, including contacts 1C and R2C, becomes first energised and then de-energised because of the closing and opening of the spin switch 335 upon the completion of one revolution. The various circuits of the stepping switch relay R6 are similar to those of Figures 21 with modifications which it is thought will be clear from inspection of the diagrams without further description. The third circuit for the relay R6 includes contacts 1A, the cam-actuated switch 629, (which it will be recalled from Figure 31 closes only at the beginning and end of the azimuth movement), and a pushbutton switch 505.

Contacts 1A are closed in the 20° position of the stepping switch so that this circuit causes the first and last turns to be wound without any azimuth rotation of the casing.

The entire layer, except for the first and the last turns, is thus wound with the stepping switch in the 20° position. The first turn is wound when the switch is in the 10° position, and the last turn is wound when the switch is in the 30° position. In the 10° and 30° positions, the contacts 1B are open, and, therefore, the azimuth relay R5 is disconnected. Contacts 2B, however, are closed which permits the operation of the stepping switch relay R6. The operation of the relays R5 and R6, therefore, can be summarized as follows: the relay R5 is closed only during the 20° position. As soon as the rectifier 501 is energised by closing of the contacts R7C, the relay R6 is stepped from the 0° home position to the 10° position by the circuit including contacts 3A and the self-interrupting contacts 509. At 10°, contacts 1C and R2C are closed and relay R6 is stepped from 10° to 20° by closing and then opening the spin switch 335 at the end of the first complete turn. In the 20° position, winding of the entire layer, except for the first and last turns, takes place. Contact 1A is now closed, and, therefore, when the switch 629 closes and then opens at the end of the azimuth movement, the relay R6 is energised and the stepping switch is stepped from 20° to 30° position. In the 30° position, contacts 1B are open, and, therefore, the azimuth motor relay R5 is de-energised, contact 1A is open, contact 3A is open, and therefore, the only circuit that can energise the relay R6 is the circuit which includes the contacts 1C, and R2C and the spin switch 335. After completion of the last turn, the spin switch 335 closes and then opens, which steps the switch to the 40° position, thus completing the operating cycle, at which time the entire system is de-energised and contacts 3A close again to prepare the relay R6 for immediate energisation upon the starting of the next cycle.

The azimuth speed control circuit is illustrated in Figure 33 which is a modified version of Figure 20. Elements, corresponding to those in Figure 20, bear the same reference numerals, and only the parts that differ will be described.

The main difference resides in the introduction of the cam reader 622, which is the transducer responsive to the variable height "*h*" of the cam 620 of Figure 31, which represents the desired variation in the thickness of the elastomeric layer with azimuth movement. The combined signal of the tachometer 342 and of the transducer 225 (responding to ribbon thickness) is impressed on a step-up transformer and transistor amplifier 653. The output of the amplifier 653 is fed to the primary winding 635 of the transducer 622. The opposing secondaries 645 of the transducer 622 are connected to a multi-stage transistor voltage amplifier 654 corresponding to the transistor amplifier 439 in Figure 20, of which the output feeds the full wave rectifier 440. The d.c. output of this rectifier is connected across the signal winding 462 in series opposition to the signal from the tachometer 461 in the manner described previously. The remaining connections and the function of the magnetic amplifier 463 are identical with those described in connection with Figure 24, and, therefore, need no additional description.

From the description of Figure 33, as compared with Figure 20, it follows that the difference between the two figures resides in the elimination of resistors 443-446 and of the stepping switch contacts 1B, 2B, 3B and 7B, whose function has been transferred to the transducer 622 which scans and responds to the variable height, or amplitude, of the cam 620. Smoother transitions and finer adjustment of the desired thicknesses of the elastomeric layer can be obtained with the system disclosed in Figure 33 than can be obtained with the system of Figure 20.

The programmer in the second method is simpler than the first, sector method, and there are no sudden changes in the azimuth speed in the second method, which always is an advantage in any variable speed system. By the same token, the variable speed system is more advantageous than any start-stop system since any sudden starts and sudden stops are difficult to achieve with a high degree of accuracy, and especially so when high speed operations are contemplated.

METHOD 2 INCLUDING BEAUTY RINGS

Figures 36, 37 and 38 illustrate the second method, i.e., the same type of system and method as that illustrated in Figures 31 to 35 but applied to the retreading of used tyres (or to the making of new tyres, as shown in Figures 22 and 23) which require

windin[illegible]o beauty rings 563.

Figur[illegible]llustrates a programme cam 661 similar to the cam 620 of Figure 31, but modified to include two beauty rings located at the desired portions of the side walls. Since there is no azimuth movement while the beauty rings are wound, it becomes necessary to interrupt the azimuth movement twice at the desired moments during the ribbon-winding cycle. This is the system disclosed below which uses the second method, i.e., the variable amplitude cam.

In Figure 36 the switch 662 has only one switch 629 which now stops the azimuth motor and the cam-scanning movement three times (instead of only once as in Figure 31) namely, twice for winding two beauty rings, and once more at the end of the cam-scanning cycle, one revolution ahead of the termination of the ribbon-winding cycle and stopping of the spin motor. For this purpose three indentations 663, 664, and 665 are formed in the lower edge 666 of the cam. Indentations 663 and 664 are located along the lines 667 and 668 which coincide with the corresponding positions of the left edges of the two beauty rings along the X axis of the cam 661, while the indentation 665 corresponds to the position of the left edge of the last turn produced without any azimuth movement. To avoid scanning the indentations 663, 664 and 665, the azimuth starting switch 628 has now been transferred to engage a side-face 669 of the cam 661 and this face is now provided with an outwardly or inwardly projecting indentation 670 corresponding to the indentation of the programme card in Figure 12 which indicates the desired azimuth starting point along the X axis of the cam. The switch 671 is actuated when its scanning arm 672 engages the indentation 670. The casing 150 and wheel 151 of Figures 5 and 6 are then in the proper azimuth starting position and the circuit of the amber azimuth lamp 415 of Figure 32, becomes closed.

The transducer 622 performs the same function in Figure 36 as in the earlier figures. All these cam-scanning elements 632, 672 and 630 are vertically aligned with respect to each other so that the electrical signals produced by these three elements are properly synchronized with respect to their common position along the X axis.

Figure 38 illustrates the operation of the four cams which are required for operating the programmer, and Figure 37 illustrates only that portion of the schematic diagram which differs from that shown in Figures 32 and 34. The remaining portion of the programmer of Figure 37 is identical to that shown in Figures 32 and 34.

Cam No. 1 has detents at 20°, 60° and 100°; cam No. 2 has a detent from 10° to 110°; cam No. 3 has detents at 0°, 50°, 90° and 12[illegible]d cam No. 4 has detents at 0°, 40°, 80° [illegible]d 120°.

In Figure 37 the holding circuit of the relay R7 now includes contacts R7B connected in series with two stepping switch contacts 2A and 3C, shunted by a high resistor 680 which acts as an arc suppressor.

Examination of Figure 38, bearing in mind that a cross means that the corresponding contacts A and B are closed and C is open, indicates that contact 2A and 3C are open in the "home" positions of the stepping switch, which are the 0° and 120° positions. Contact 2A remains closed from 10° to 110°. Contact 3C opens the 0°, 50°, 90° and 120° positions; therefore, relays R7 and R3 remain energised between 10° and 120°, inclusive, which means that the extruder cam remain energised during the entire operating cycle and is de-energised at the home position of the stepping switch, as in the earlier programmers.

The only remaining change relates to the beauty ring selector switch 512 which now is included in the circuit of the relay R6 in the same manner as the similarly numbered switch in Figure 21. The two contacts which are now in series with this switch are contacts 3B and 4B which perform the same function as contacts 5A and 6A in Figure 21. As explained earlier in connection with Figure 21, the number of turns wound at the beauty ring positions, with 100% overlap, depends on the setting of the switch 512 which determines the number of turns the wheel of the casing must make in order to step the stepping switch from 30° to 60° and from 70° to 100°. It will be noted that from 30° to 50° inclusive and from 70° to 90° inclusive contacts 1B are open, heating the circuit of the azimuth relay R^5 and stepping the azimuth motor. Thus azimuth movement starts again only when the stepping switch reaches position 60° or position 100°.

The maximum number of turns is three, the minimum is one. These turns are counted by the spin switch 335. This beauty ring system, using the second method is applicable to new and used tyres.

The operation of this circuit was described twice before, first in connection with Figure 21 and then in connection with Figure 24 and it is thought unnecessary to repeat it in detail.

METHOD 3. START-STOP VARIABLE DURATION AZIMUTH MOVEMENT

Figure 39 relates to the Method 3 of winding in which the azimuth speed remains constant but the duration of azimuth movement during each spin revolution is varied in order to control the pitch and therefore overlap of successive turns of the winding.

The machine is very similar to that shown in Figures 5 to 16, and it will suffice to refer to the parts that differ.

In Figure 5 a tacho[illegible] 461 is provided on the azimuth motor 2[illegible]ut is not required in Method 3. In addition, the spin tachometer 342 of Figures 14 and 15 is omitted, but the spin switches 334, 335 and 336 are supplemented by a fourth spin switch 704.

The fourth spin switch is embodied in the timing circuit described below in connection with the upper part of Figure 39 whereas the spin tachometer required in Methods 1 and 2 to control the azimuth speed in relation to the spin speed is not required in Method 3.

Since the azimuth motor is continually starting and stopping in Method 3, it is important that it should be of a suitable type.

Thus the azimuth motor may be a three-phase induction motor geared down to produce a speed of approximately 8.5 r.p.m. at the azimuth shaft 157. It is, however, preferable to employ a stepping motor which turns through a fixed angle for each cycle. This may be of the type known as slow-speed synchronous motors having a large number of poles, for example, 100 poles. A motor of this type, for example, is one of the motors sold under the trade mark SLO-SYN by the Superior Electric Company of Bristol, Connecticut and described in Bulletin SE.L 2604. Such a motor enables the amount of azimuth rotation to be accurately controlled without the variable time lag in starting and stopping that is liable to occur with an induction motor, especially as a result of erratic coasting after the motor has been de-energised. The synchronous motors referred to lock instantly into a magnetic "hold" position when de-energised, thus eliminating any coasting.

The difference in windings produced by Method 3 and Method 1 have already been described in connection with Figures 3 and 4. The difference in the machines is largely concerned with their electrical control means and will be evident from the circuit diagrams. The general circuit diagram of Figure 18 is common to both methods except that the rectangle 402 representing the azimuth speed control of Figure 20 is replaced by a timing circuit for determining the duration of azimuth movement during each spin revolution. Figure 39 shows this timing circuit in addition to the stepping and relay circuits so that Figure 39, in fact, replaces both Figures 20 and 21. Figure 19 showing the spin motor speed control is the same for Method 3 as it is for Methods 1 and 2.

Comparing the lower part of Figure 39 with Figure 21, it will be seen that the two circuits are very similar. In fact, the only difference is that in Figure 39 the circuit of the relay R5 also includes normally closed contacts R8A of a timer relay R8 and a second contact of the spin switch 335. Accordingly, the azimuth motor will only run while the timer relay R8 is [illegible]gised. This is arranged to occur for [illegible]redetermined period at the beginning of each spin revolution, under the control of the timer circuit shown in the upper part of Figure 39. The table of operations of the stepping switch in Figure 17 applies equally to this embodiment, but the timer circuit has no counterpart in the circuit employed for Methods 1 and 2 and will now be described.

TIMER AND STEPPING SWITCH CIRCUITS

The upper part of Figure 39 shows the circuit of the timer. The basis of the timer is the charging of a capacitor 685 through one or other of a number of manually adjustable resistors 686, 687, 688 and 689 from a controlled d.c. supply. The d.c. supply is obtained from a transformer 690 connected between the terminals 409 and 405 and supplying a full wave rectifier connected in a filtering network 691 including two resistors, three capacitors and a zener diode. The timing resistors 686 to 689 are connected respectively in series with contacts 1A, 2A, 3A and 7A of the stepping switch in four parallel branches. These are connected in series with the timing capacitor 685 and normally closed contacts 692 of the spin switch 704 across the d.c. supply represented by the zener diode.

The spin switch 704 also has a normally open contact 693 and the timing capacitor is connected between this contact and its common contact 694 so as to be short-circuited and discharged at the end of each spin revolution of the tyre casing. Hence at the beginning of each spin revolution the capacitor 685 is fully discharged, and then, when the spin switch 704 moves to the contact 692, it begins to charge up through whichever of the resistors 686 to 689 is selected by the spin switch contact 1A, 2A, 3A or 7A. The timing circuit also includes a series circuit between the points 695 and 694, namely, earth and the common terminal 694 of the spin switch 704. This includes a resistor 696, a resistor 697, a diode 698, a PN uni-junction transistor 699 and a resistor 700. Also connected between the same points are a timer relay R8 and a silicon controlled rectifier 701 having a gate electrode 703 connected to the second base of the transistor 699, that is to say its junction with the resistor 700. The emitter of the transistor 699 is connected to the contact 693, that is to say the junction between the timing capacitor 685 and the contacts 1A, 2A, 3A and 7A.

A ribbon thickness bias is applied to the junction 702 between the resistors 696 and 697, which may be termed the ribbon bias point.

OPERATION OF THE TIMING CIRCUIT

The operation of the timing circuit is as

follows. At any given time as shown in Figure 17, only one of the stepping switch contacts 1A, 2A, 3A and 7A is closed, so that one of the resistors 686 to 689 will be connected in circuit.

When the tyre casing completes a spin revolution the spin switch moves to the contact 693 and completely discharges the capacitor 685. Then as the next spin revolution begins the spin switch returns to the contact 692 and the capactior 685 begins to charge up until the potential across it causes breakdown of the transistor 699. The transistor 699 has a negative resistance characteristic and hence when it becomes conductive its resistance between its emitter and base 1 is immediately lowered so that the capacitor 685 is discharged through the transistor 699 and resistor 700. The resistor 700 is connected across the cathode and gate of the silicon controlled rectifier 701 and hence the flow of current through the resistor 700 impresses a positive pulse on the gate electrode 703 causing the rectifier to conduct and energise the relay R8. Throughout the remainder of the spin revolution while the spin switch 704 is on the contact 692, the capacitor 685 will go on alternatively discharging and charging with the action of a relaxation oscillator but this has no effect on the relay R8 since once the silicon controlled rectifier 701 has fired, it remains conductive irrespective of the potential applied to its gate electrode. Hence the relay R8 remains energised for the remainder of the spin revolution, that is to say, until the circuit is broken by the return of the spin switch 704 to the contact 693, whereupon the silicon controlled rectifier 701 again becomes non-conductive and remains non-conductive until its gate electrode receives another positive pulse.

The circuit for energisation of the stepping relay R6 is precisely analogous to that described in connection with Figure 21, and the general operation is similar to that described in connection with Figures 5 to 21 and it is thought unnecessary to repeat the description.

Hence the azimuth motor is stopped as long as the silicon controlled rectifier 701 is conducting, namely from the time it fires due to charging of the capacitor 685 through the selected one of the programme resistors 686 to 689 to the end of the spin revolution when its circuit is broken by the spin switch 704.

It is thought that it will be clear how such an arrangement may be used to produce the type of winding already discussed in connection with Figure 4.

Similarly for making new tyres Method 3 may be employed with a machine similar to that shown in Figure 22.

It will be appreciated that the invention is not limited to the embodiments described by way of example so far, as many modifications may be made.

One specific modification that may be mentioned relates to the feeding of the elastomeric material to the extruder. In this modification the material, after being stacked on a pallet as a zig-zag stack of inter-connected rectangular slabs (like accordian bellows), is fed to a chopper and thence direct to the extruder. The chopping machine may be generally of known construction. A slab of the material is fed intermittently under a raised guillotine knife, the knife is lowered to cut off a strip, which is gripped between a plate descending with the knife and a part-cylindrical door pivoted about its axis. The plate and door then swing away from the knife to a partially retracted position to tear the cut strip clear of the knife; the plate and knife are then raised again; and the door is fully retracted to allow the strip to drop onto a conveyor by which it will be carried away lengthwise to the extruder. This cycle of operations is under the control of a timer. The conveyor for feeding the cut strips to the extruder is provided with feeler contacts the actuation of which depends on whether there is a cut strip on the conveyor, and these contacts are arranged to control the timer so as to stop the cycle so long as there is a cut strip on the conveyor. Hence if the extruder will cease to operate until it does so. Accordingly, the speed of the extruder controls both the speed of the spin motor taking the ribbon from it, and the action of the chopper supplying strips to it.

COMPARISON OF THE START-STOP SYSTEM WITH THE VARIABLE SPEED SYSTEM

In the introductory part of the specification it has been mentioned that it is possible to obtain azimuth movement by using two basic systems.

The first system used in Methods 1 and 2 is the variable speed system in which the azimuth movement is continuous throughout the entire winding cycle except for the first and last turns (and possibly the winding of beauty rings) when there is no azimuth movement. The other system is the one employed in Method 3 in which the azimuth movement takes place during a fraction of each spin revolution and then is stopped, whereupon the 360° turn is finished with no azimuth movement. When the start-stop system is compared with the continuous variable speed system, one arrives at the following conclusions: it is possible to obtain a higher precision and accuracy with the variable speed system because it has a much wider range of azimuth adjustment than the start-stop system. Stated differently the minimum as well as the maximum displacement of the ribbon per revolution can be obtained more readily with the variable speed system than with the start-stop system,

and this is especially so far as the minimum displacement is concerned. In the start-stop system one can reach such limits as a fraction of a second for connecting and disconnecting the azimuth motor. It is obvious that the electrical and mechanical inertias preclude such rapid starting and stopping. Moreover, when such rapid starting and stopping is attempted, problems are encountered with the stitching of the ribbon.

The variable speed system, therefore, for all practical purposes, is the only system that can function effectively and accurately when very fast operation is desired and also when heavy equipment for retreading heavy duty tyres and off-the-road tyres or making of new off-the-road tyres is under consideration.

This specification discloses two types of variable speed systems. In the first method the azimuth speed is changed from sector to sector, while in the second method the azimuth speed is varied by a variable amplitude cam, and therefore, there may be a continuous variation in the azimuth speed. The most flexible and accurate system, and the system that has the widest range, is the one in which the azimuth speed may have any number of variations. Therefore, it is the preferred system.

WHAT WE CLAIM IS:—

1. A machine for depositing a variable thickness layer of elastomeric material on a tyre casing which comprises means for supporting the casing, a feeding head for applying to the casing a ribbon of the elastomeric material of which the width is several times the thickness, means for rotating the casing about its axis, referred to herein as the spin axis, to wind on the casing a winding comprising a substantial number of turns as the casing rotates relatively to the feeding head, means for moving the feeding head transversely relatively to the casing, referred to herein as azimuth movement, from one side to the other of the mid-circumferential plane of the casing, to produce a winding which extends from a position on one side of the mid-circumferential plane of the casing across the said mid-circumferential plane to a position on its other side, and of which successive turns partially overlap, and means for automatically varying the azimuth movement per spin revolution of the casing to cause the turns of the winding to overlap to a varying degree, thereby varying the thickness of the layer.

2. A machine as claimed in Claim 1 in which the width of the ribbon is between five and thirty times its thickness.

3. A machine as claimed in Claim 1 or Claim 2 in which the width of the ribbon is greater than the maximum thickness of the layer.

4. A machine as claimed in any one of the preceding claims in which the azimuth movement is a movement of relative translation along the axis of the casing.

5. A machine as claimed in Claim 4 for winding a casing of cylindrical form, for example for a new tyre.

6. A machine as claimed in any one of Claims 1 to 5 for winding a casing of generally part-toroidal form, for example for retreading.

7. A machine as claimed in Claim 6 in which the azimuth movement is a movement of relative rotation about an azimuth axis tangential to the circular axis of the toroid.

8. A machine as claimed in any one of the preceding claims in which the stitching point remains substantially stationary and the azimuth movement is imparted to the casing.

9. A machine as claimed in Claim 7 in which the ribbon is applied by a stitching head which is movable towards and away from the casing.

10. A machine as claimed in Claim 9 in which means is provided for applying pressure to the stitching head to press the ribbon onto the casing.

11. A machine as claimed in Claim 10 in which the stitching head has stitching rollers through which the stitching pressure is applied to the ribbon.

12. A machine as claimed in Claim 11 in which the stitching rollers are independently movable towards and away from the casing and are urged towards it by fluid pressure.

13. A machine as claimed in any one of Claims 9 to 12 in which the stitching head carries a driven spin wheel which serves to drive the casing about the spin axis.

14. A machine as claimed in any one of Claims 9 to 13 in which the stitching head is carried by an arm pivoted to enable the stitching head to move towards and away from the casing.

15. A machine as claimed in any of Claims 7 to 14 including means for adjusting the spin axis of the casing towards and away from the azimuth axis.

16. A machine as claimed in any one of Claims 7 to 15 in which the azimuth axis is vertical.

17. A machine as claimed in any one of Claims 7 to 16 in which the means for supporting the casing comprise an azimuth shaft mounted to turn about its axis, a radial arm carried by the azimuth shaft, a column supported by and projecting up from the radial arm, and an adjustable arm pivoted at its lower end on the radial arm and carrying a spin bearing and means for supporting the casing on the spin bearing, and means for adjusting the angular position of the adjustable arm relative to the upstanding column.

18. A machine as claimed in Claim 17 in

which the radial arm extends obliquely to the spin axis.

19. A machine as claimed in any one of Claims 7 to 18 including means for measuring the overall radius of the casing.

20. A machine as claimed in Claim 19 including a chart, cooperating with the adjustable support, for setting the distance between the spin axis and the azimuth axis in accordance with the overall diameter of the casing and the desired radius of the tyre about the azimuth axis.

21. A machine as claimed in any one of the preceding claims in which the winding comprises a number of sectors including two shoulders and a crown, the overlap and thickness being greater in the shoulder sectors than in the crown sector.

22. A machine as claimed in Claim 21 in which the winding also includes two side wall sectors in which the overlap and thickness is less than it is in the crown sector.

23. A machine as claimed in Claim 22 in which the winding also includes a beauty ring, wound without azimuth movement, on one or each side.

24. A machine as claimed in Claim 23 in which the winding includes two or more beauty rings on one or each side wound successively without azimuth movement and hence with 100% overlap.

25. A machine as claimed in any one of Claims 21 to 24 in which the azimuth movement per spin revolution, and hence the overlap between successive turns, assuming constant ribbon thickness, is kept constant in each sector but is changed between one sector and another.

26. A machine as claimed in any one of claims 21 to 24 in which the azimuth movement per spin revolution is varied during individual sectors of the winding.

27. A machine as claimed in any one of the preceding claims in which the azimuth movement occurs at substantially constant speed but only for a fraction of each spin revolution, the said fraction being varied to vary the azimuth movement per spin revolution.

28. A machine as claimed in Claim 27 in which the azimuth movement begins at the same point in each revolution.

29. A machine as claimed in Claims 1 to 20 in which the azimuth movement is a continuous movement and the speed of the azimuth movement is varied in accordance with the required thickness of the elastomeric layer to be deposited on the casing.

30. A machine as claimed in any one of the preceding claims including an extruder from which the ribbon is supplied in a hot state direct to the casing.

31. A machine as claimed in Claim 30 including a chopper for automatically chopping slabs of the elastomeric material into strips and feeding the strips to the extruder and means for controlling the chopper automatically in accordance with the rate at which the extruder accepts the strips.

32. A machine as claimed in Claim 30 or Claim 31 including means for controlling the spin speed in response to the rate of supply of ribbon from the extruder.

33. A machine as claimed in Claim 32 in which the spin speed is controlled in accordance with the position of a dancer roller movably mounted and biased to take up slack ribbon between the extruder and the stitching point.

34. A machine as claimed in Claim 33 in which the dancer roller actuates a variable resistor.

35. A machine as claimed in Claim 33 or Claim 34 in which the movement of the dancer roller controls a semi-conductor (e.g. silicon) controlled rectifier in the circuit of a d.c. motor driving the casing about its spin axis.

36. A machine as claimed in Claim 33 or Claim 34 in which the dancer roller also controls tight-ribbon switch contacts which it actuates to stop the spin motor if the ribbon tightens beyond the range of speed control.

37. A machine as claimed in any one of the preceding claims including means dependent on ribbon thickness for modifying the azimuth movement per spin revolution.

38. A machine as claimed in any one of the preceding claims including means dependent on ribbon thickness for actuating an indicator giving a measure of ribbon thickness.

39. A machine as claimed in Claim 37 or Claim 38 in which the means dependent on ribbon thickness comprise a ribbon thickness transducer in the form of a differential transformer having a movable core, and a sensing member responsive to ribbon thickness arranged to control movement of the core.

40. A machine as claimed in any one of the preceding claims including a programme unit having interchangeable keys corresponding to different types of tyre, and scanning means for scanning a selected key in synchronism with the azimuth movement, the key being formed to actuate the scanning means in the azimuth movement to modify the rate of azimuth movement per spin revolution.

41. A machine as claimed in Claim 40 in which the key is in the form of a variable height cam.

42. A machine as claimed in Claim 40 in which the key is in the form of a plate, which will be referred to as a programme card.

43. A machine as claimed in Claim 40 or Claim 42 in which the key has projections or recesses to actuate switches associated with

the scanning means at appropriate points of said key.

44. A machine as claimed in any one of Claims 40 to 43 in which the key is arranged to actuate scanning switch contacts at an azimuth starting position appropriate for starting the winding, which contacts control a starting circuit to prevent starting of the programme except when the casing is in the azimuth starting position.

45. A machine as claimed in any one of Claims 40 to 44 in which the key is arranged to actuate scanning switch contacts at an azimuth starting position appropriate for starting the winding, which contacts control an indicator (e.g. a lamp) to indicate to an operator that the casing is in the azimuth starting position.

46. A machine as claimed in any one of the preceding claims including a spin switch arranged to be actuated when the casing is at a predetermined spin starting position about the spin axis.

47. A machine as claimed in Claim 46 in which the spin switch controls a starting circuit to prevent starting of the programme except when the casing is in the spin starting position.

48. A machine as claimed in Claim 46 or Claim 47 in which the spin switch controls an indicator (e.g. a lamp) to indicate to an operator that the casing is in the spin starting position.

49. A machine as claimed in any one of the preceding claims including a stepping switch having a number of positions corresponding to different stages of the winding cycle, and means responsive to a stepping pulse for moving it from one position to the next.

50. A machine as claimed in any one of Claims 46 to 48 and as claimed in Claim 49 in which the stepping switch has a "first turn" position in which it stops movement of the azimuth motor to wind a zero-pitch first turn, and the spin switch is arranged to cause a pulse to be delivered at the end of the said turn to advance the stepping switch to its next position.

51. A machine as claimed in any one of Claims 46 to 48 and as claimed in Claim 49 or Claim 50 in which the stepping switch has a last-turn position in which it stops movement of the azimuth motor to wind a zero-pitch last turn, and the spin switch is arranged to deliver a pulse at the end of the said turn to advance the stepping switch to its next position.

52. A machine as claimed in any one of Claims 46 to 48 and as claimed in any one of Claims 49 to 51 in which the stepping switch has at least one beauty ring position in which it stops movement of the azimuth motor to wind a zero-pitch beauty ring, and the spin switch is arranged to deliver a pulse at the end of the said turn to advance the stepping switch to its next position.

53. A machine as claimed in Claim 52 in which the stepping switch has at least one group of two or more beauty ring positions in each of which it stops movement of the azimuth motor, so as to wind two or more zero-pitch beauty rings one on top of the other with 100% overlap, and the spin switch is arranged to deliver a pulse at the end of each beauty ring to advance the stepping switch to its next position.

54. A machine as claimed in any one of Claims 49 to 53 including self-interrupting contacts which can be connected in circuit with the stepping switch to cause it to advance rapidly through successive positions until the said circuit is interrupted.

55. A machine as claimed in Claims 53 and 54 including a beauty ring selector switch cooperating with the self-interrupting contacts to determine the position of the stepping switch at which it will be connected in circuit with the self-interrupting contacts so as to be rapidly advanced to omit further beauty rings.

56. A machine as claimed in Claim 50 and any one of Claims 52 to 55 in which a beauty ring coincides with the first turn.

57. A machine as claimed in Claim 51 and any one of Claims 52 to 56 in which a beauty ring coincides with the last turn.

58. A machine as claimed in any one of Claims 52 to 55 in which one or more beauty rings are wound between a first and second portion of a side wall, (e.g. for a new tyre).

59. A machine as claimed in any one of the preceding claims in which the casing has beads and the layer has side wall portions extending beyond them to be later folded round them.

60. A machine as claimed in Claim 40 and as claimed in any one of Claims 41 to 59 in which the key includes a cam cooperating with a cam follower to control the movement of a transducer which controls the azimuth speed.

61. A machine as claimed in Claim 60 in which the transducer comprises a differential transformer having a movable core actuated by the cam follower.

62. A machine as claimed in any one of Claims 43 to 45 and as claimed in any one of Claims 49 to 58 in which the programme unit is arranged to deliver a stepping pulse to the stepping switch at the azimuth position corresponding to the beginnnig of each sector, to advance it to the position appropriate to that sector.

63. A machine as claimed in any one of Claims 30 to 59 in which the amount of azimuth movement per spin revolution is controlled by the effective value of a programme resistor.

64. A machine as claimed in Claims 62

and 63 in which the effective value of the programme resistor is determined by the position of the stepping switch.

65. A machine as claimed in Claim 63 or Claim 64 including a number of programme resistor branches one for each sector, and switch means for bringing them into circuit successively.

66. A machine as claimed in Claim 65 in which each branch is independently variable.

67. A machine as claimed in Claim 65 or Claim 66 in which each branch includes one of a number of ganged selector switches and the portion selected thereby of a chain of resistors.

68. A machine as claimed in any one of Claims 42 to 67 in which the programme card also has non circular apertures, referred to as interlocking apertures, shaped to fit over manual adjusting members, referred to as knobs, only when such members are in predetermined positions.

69. A machine as claimed in any one of Claims 64 to 67 and as claimed in Claim 68 in which the programme card has an interlocking aperture for the adjusting member of each programme resistor.

70. A machine as claimed in Claim 55 and as claimed in Claim 68 or Claim 69 in which the programme card has an interlocking aperture for the operating member of the beauty ring switch.

71. A machine as claimed in Claim 67 and as claimed in any one of Claims 68 to 70 in which the programme card has an interlocking aperture for the operating member of the ganged programme resistor selector switches.

72. A machine as claimed in any one of Claims 63 to 67 or of Claims 69 to 71 in which the value of the programme resistor controls the speed of a motor producing the azimuth movement.

73. A machine as claimed in Claim 60 or Claim 72 in which the azimuth movement is produced by a d.c. motor supplied through a semi-conductor (e.g. silicon) rectifier, controlled to vary its speed.

74. A machine as claimed in Claim 73 in which the silicon rectifier is controlled by the output of a magnetic amplifier.

75. A machine as claimed in Claim 73 or Claim 74 in which the speed of the azimuth motor is controlled by a signal including a component supplied from a spin tachometer so that the azimuth speed varies with the spin speed.

76. A machine as claimed in Claim 37 and as claimed in Claim 75 in which the signal includes a component supplied by a ribbon thickness transducer.

77. A machine as claimed in Claim 60 and any one of claims 73 to 76 in which the signal also includes a component from the transducer actuated by the cam follower in accordance with the desired thickness of the elastomeric layer at each azimuth position.

78. A machine as claimed in any one of Claims 73 to 76 in which the speed of the azimuth motor is controlled by a signal including a component supplied by an azimuth tachometer to provide negative feedback.

79. A machine as claimed in Claim 27 and any one of Claims 63 to 67 in which the duration of azimuth movement in each spin revolution is determined by the period required for a capacitor to be charged to a certain level through a programme resistor.

80. A machine for winding a variable thickness elastomeric layer on a tyre casing as specifically described herein with reference to Figures 1 to 3, Figure 4, Figures 5 to 17, Figures 18 to 21, Figures 22 to 24, Figures 25 to 30, Figures 31 to 33, Figures 34 to 38 or Figure 39 of the accompanying drawings.

81. A method of retreading a tyre using a machine as claimed in any one of the preceding claims.

82. A method of making a tyre using a machine as claimed in any one of Claims 1 to 80.

83. A method of applying a variable thickness layer of elastomeric material to a tyre casing, which comprises supplying to the casing, from a point that will be termed a feeding point a continuous ribbon of the elastomeric material whose width is several times its thickness, producing relative rotation between the tyre casing and the feeding point about the normal axis of rotation of the tyre casing (referred to as the spin axis) whilst producing relative transverse movement between the feeding point and the casing, referred to herein as azimuth movement, from one side to the other of the mid-circumferential plane of the casing, to produce a winding which comprises a substantial number of turns and extends from a position on one side of the mid-circumferential plane of the casing across the said mid-circumferential plane to a position on its other side, and of which successive turns partially overlap, the amount of relative transverse movement per spin revolution being automatically varied during the winding, thereby varying the extent of overlapping and the thickness of the layer.

84. A method as claimed in Claim 83 in which the extent of overlap is such that the angle between the transverse dimension of the ribbon and the adjacent surface of the casing varies between 0° and 75°

85. A method as claimed in Claim 83 or Claim 84 in which the winding comprises a number of sectors including two shoulders and a crown, the overlap and thickness being greater in the shoulder sectors than in the crown sector.

86. A method as claimed in Claim 85 in

which the winding also includes two side wall sectors in which the overlap and thickness is less than it is in the crown sector.

87. A method as claimed in Claim 86 in which the winding includes two or more beauty rings on one or each side wound successively without azimuth movement and hence with 100% overlap.

88. A method as claimed in any one of Claims 85 to 87 in which the azimuth movement per spin revolution, and hence the overlap between successive turns, assuming constant ribbon thickness, is kept constant in each sector but is changed between one sector and another.

89. A method as claimed in any one of Claims 85 to 87 in which the speed of azimuth movement is varied during individual sectors of the winding.

90. A method as claimed in any one of Claims 83 to 87 in which the azimuth movement occurs, at substantially constant speed, during only a fraction of each spin revolution, and variation of azimuth movement per spin revolution, and hence of overlap, is obtained by variation of the said fraction.

91. A method as claimed in any one of Claims 83 to 89 in which any required variation of azimuth movement per spin revolution, and hence overlap, is obtained by variation of the speed of azimuth movement.

92. A method as claimed in Claim 91 in which any azimuth movement occurring during a spin revolution occurs throughout that revolution.

93. A method as claimed in any one of Claims 83 to 92 employing a programme unit having interchangeable keys corresponding to different types of tyre, in which a selected key is scanned in synchronism with the azimuth movement, the key being formed to actuate the scanning means at appropriate points in the azimuth movement to modify the rate of azimuth movement per spin revolution.

94. A method as claimed in Claim 91 or Claim 92 and as claimed in Claim 93 in which the key includes a cam cooperating with a cam follower to control the movement of a transducer which controls the azimuth speed.

95. A method as claimed in Claim 94 in which the transducer comprises a differential transformer having a movable core actuated by the cam follower.

96. A method of making tyres as specifically described herein with reference to Figures 1 to 3, Figure 4, Figures 5 to 17, Figures 18 to 21, Figures 22 to 24, Figures 25 to 30, Figures 31 to 33, Figures 34 to 38 or Figure 39 of the accompanying drawings.

97. A tyre made using a machine as claimed in any one of Claims 1 to 80.

98. A tyre retreaded using a machine as claimed in any one of Claims 1 to 80.

99. A machine as claimed in Claim 42 in which the programme card has a scale representing azimuth movement and means spaced along it for actuating scanning means at the appropriate azimuth positions to vary the rate of azimuth movement per spin revolution.

100. A machine as claimed in Claim 44 or Claim 45 and as claimed in Claim 99 in which the programme card has a second scale representing azimuth movement with means for actuating scanning means at an azimuth starting position.

KILBURN & STRODE,
Chartered Patent Agents,
Agents for the Applicants.

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Published at the Patent Office, 25 Southampton Buildings, London, W.C.2 from which copies may be obtained.

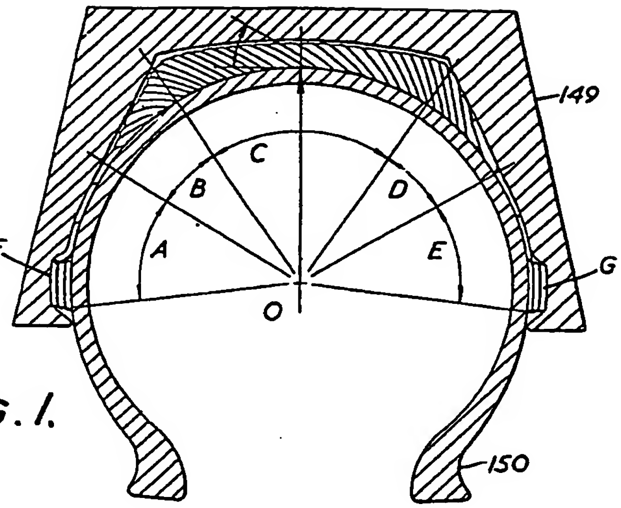


FIG. 1.

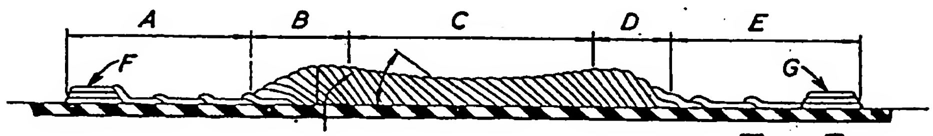


FIG. 2.

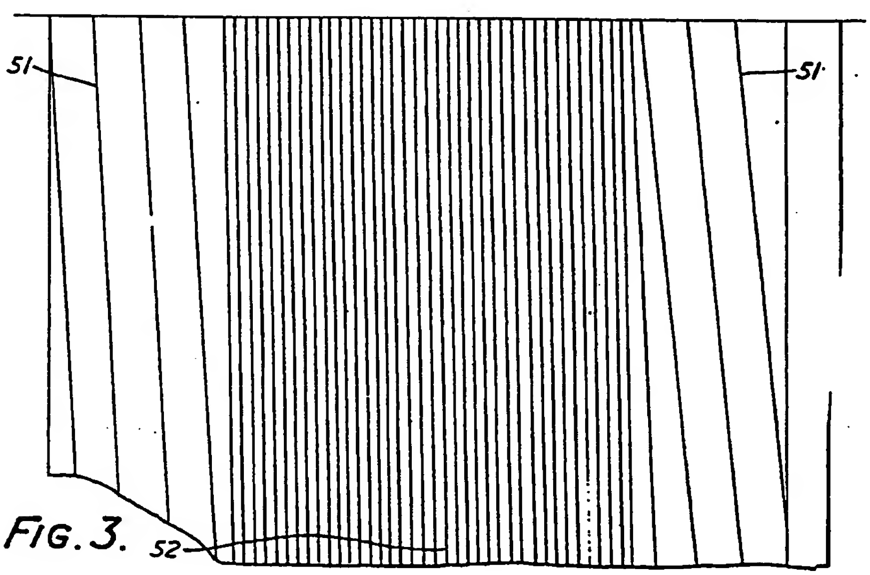
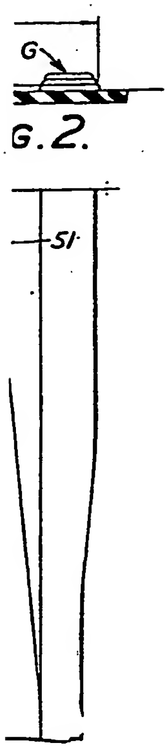


FIG. 3.

1,048,241 COMPLETE SPECIFICATION
17 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2



G.2.

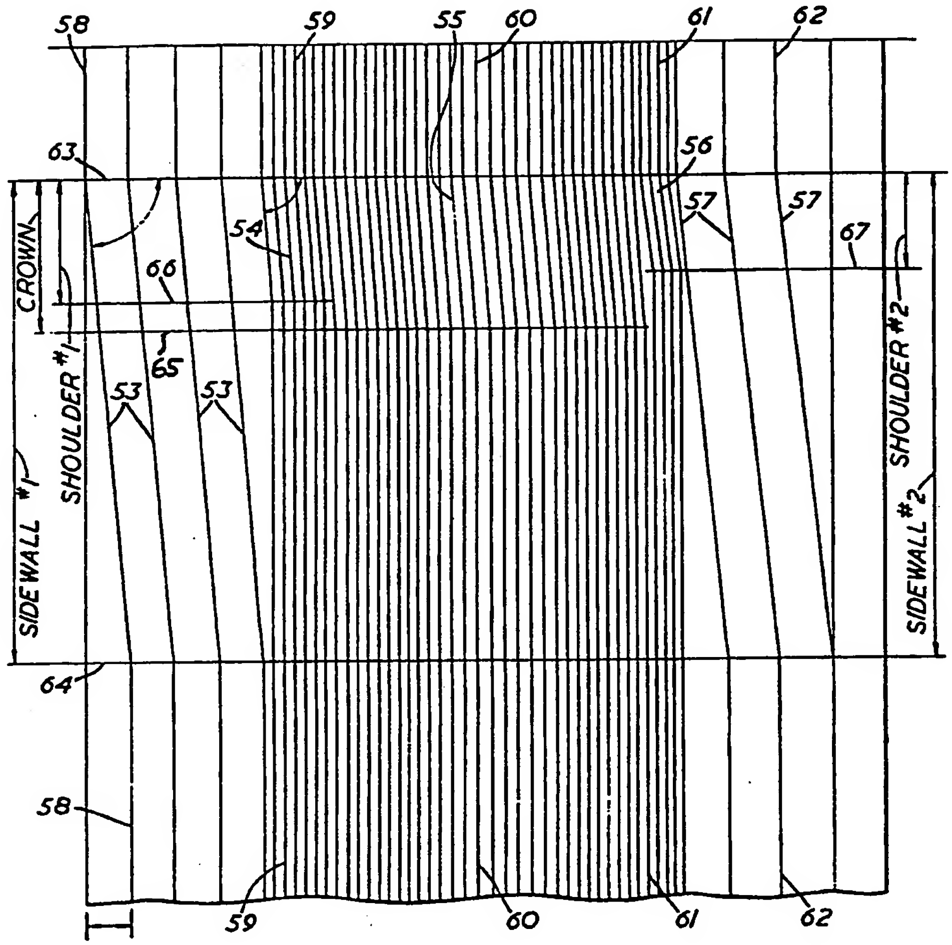


FIG. 4.

1,048,241 COMPLETE SPECIFICATION
17 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 1 & 2

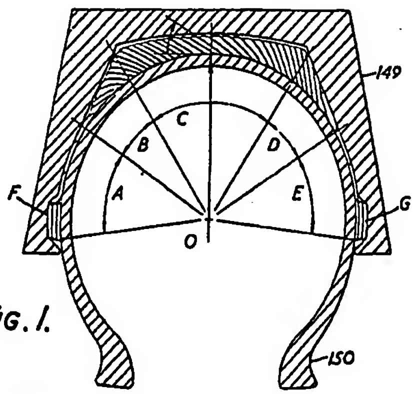
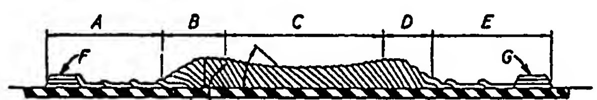


FIG. 1.



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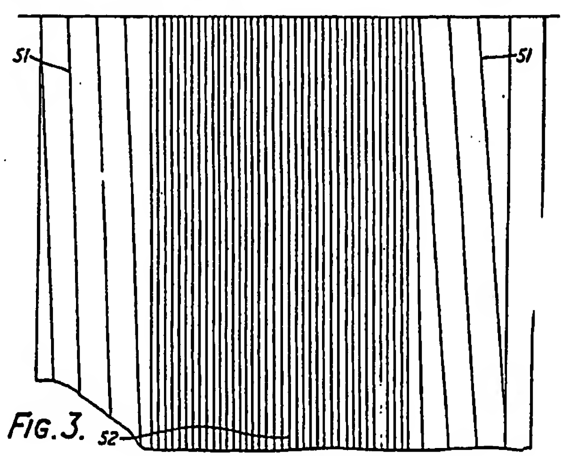

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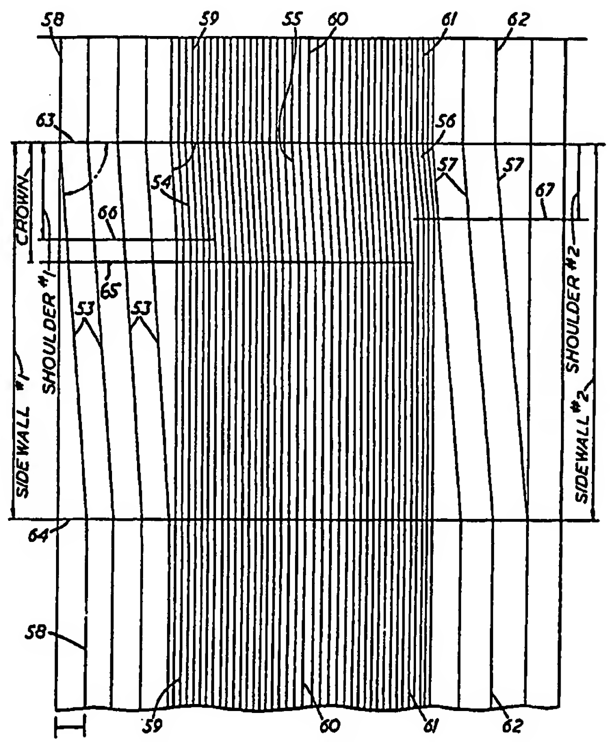

FIG. 4.

FIG. 5.

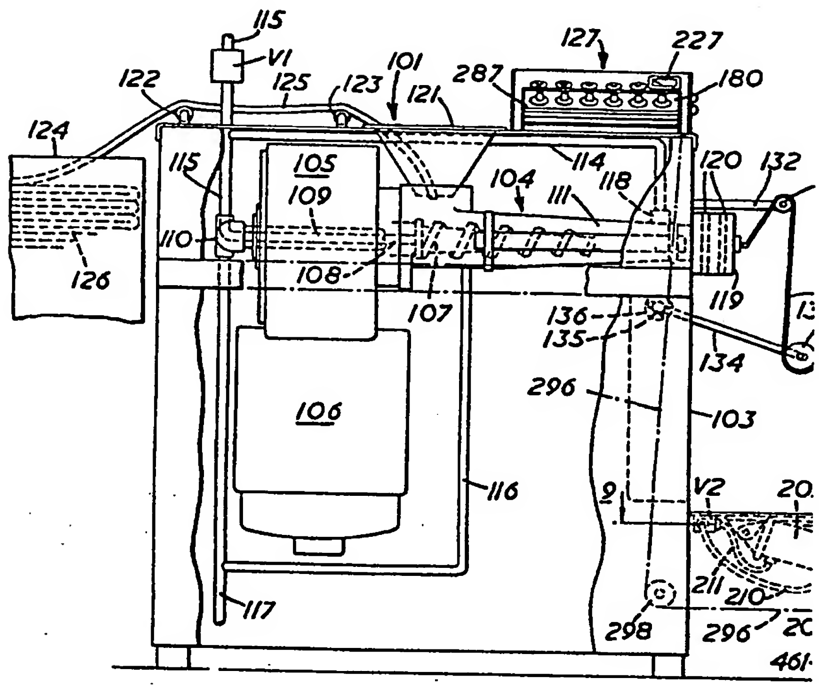
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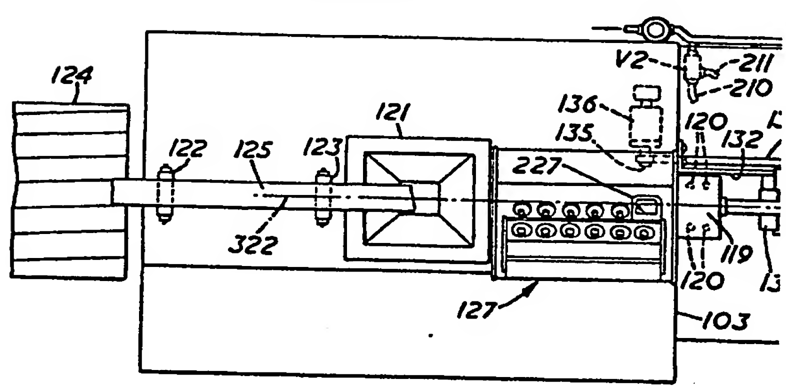
FIG. 6.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SHEET 3

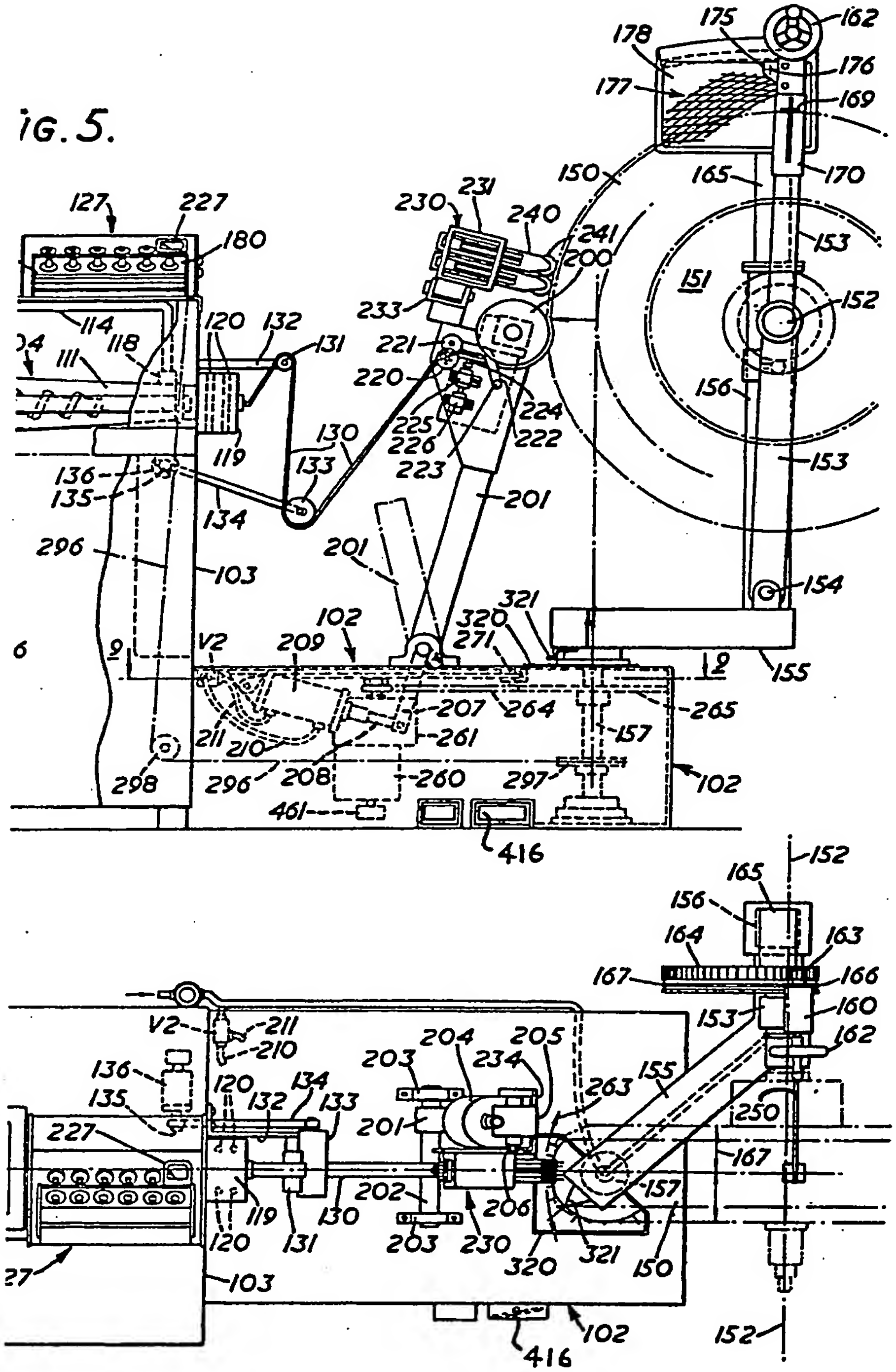

FIG. 5.

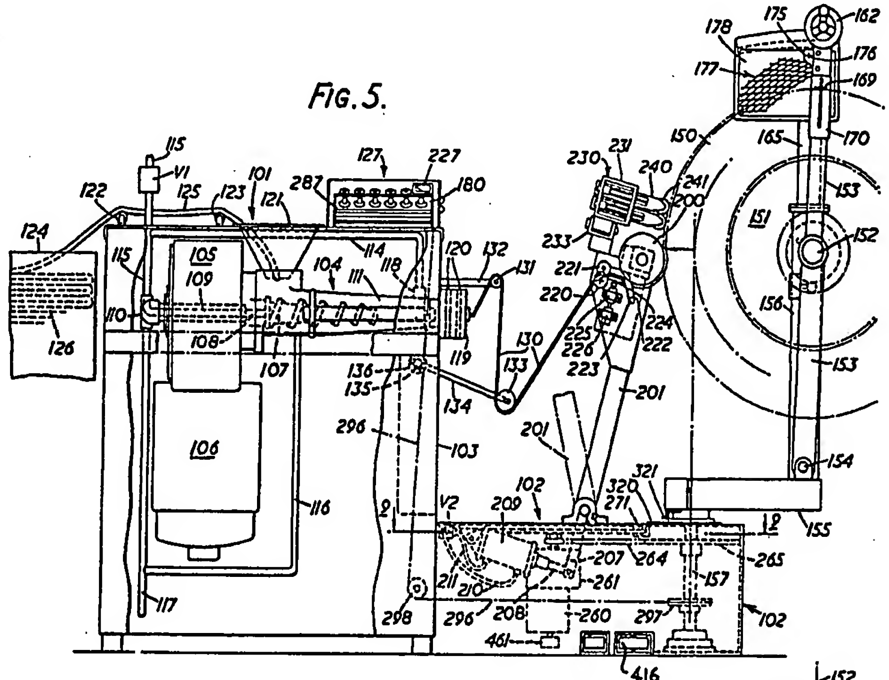
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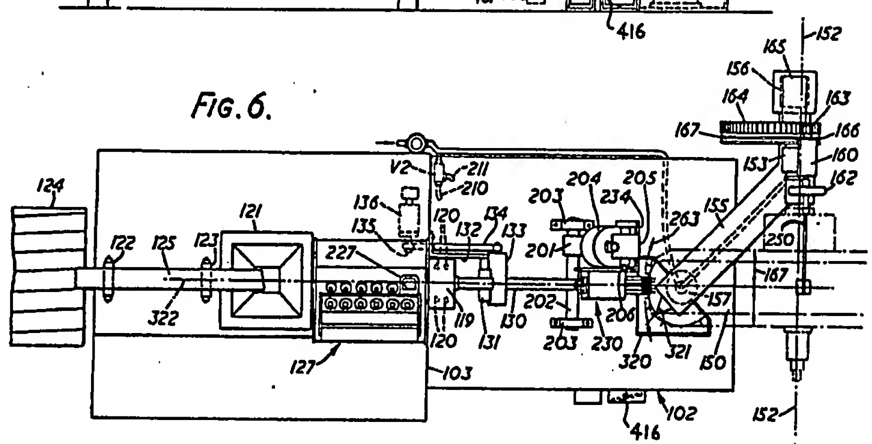
FIG. 6.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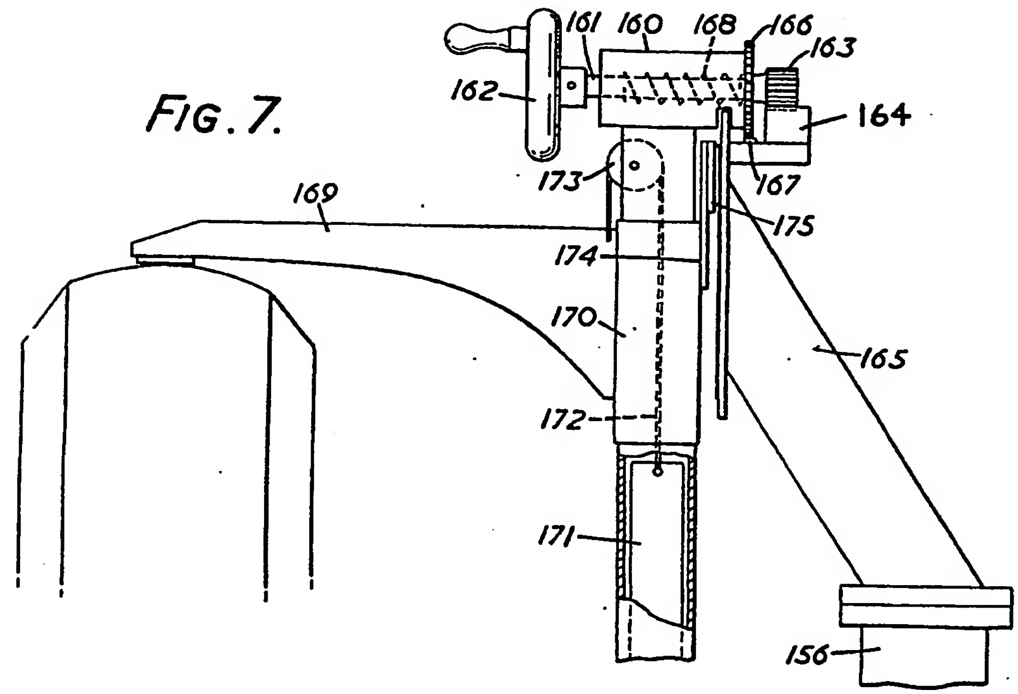

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FIG. 7.

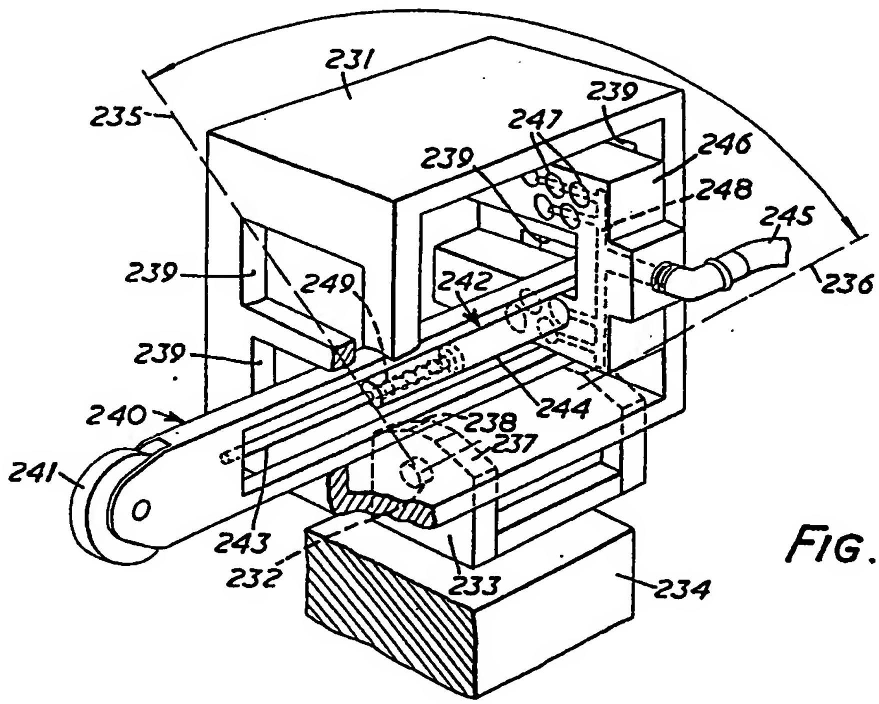

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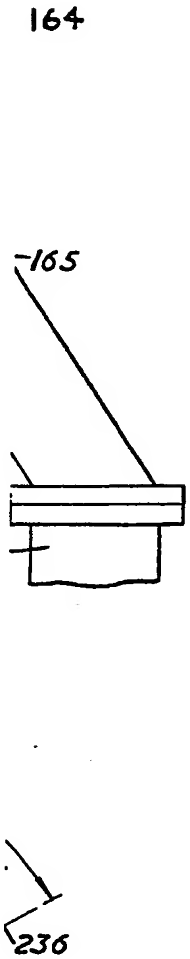
FIG. 8.



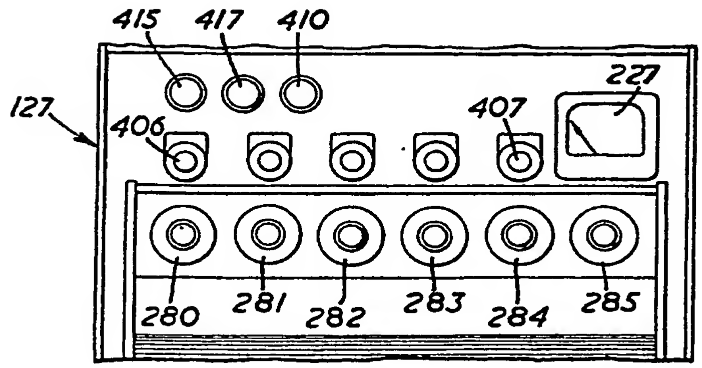


FIG. 10.

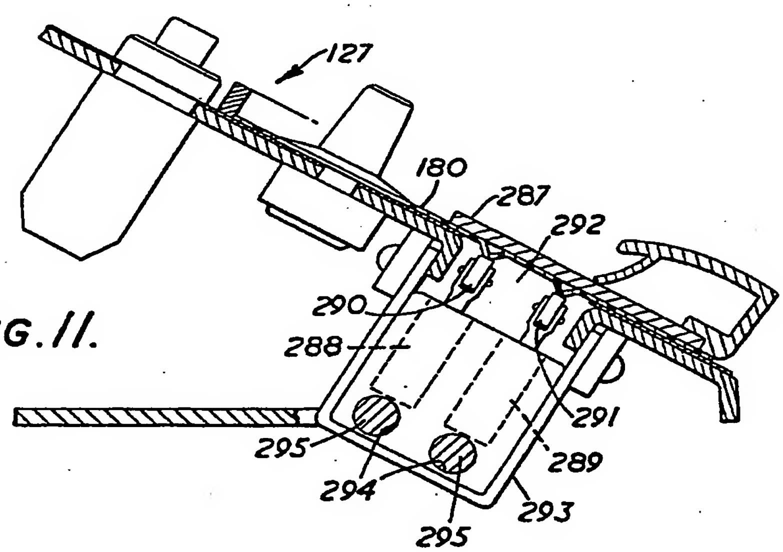


FIG. 11.

FIG. 8.

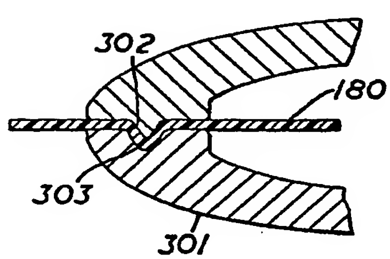


FIG. 13.

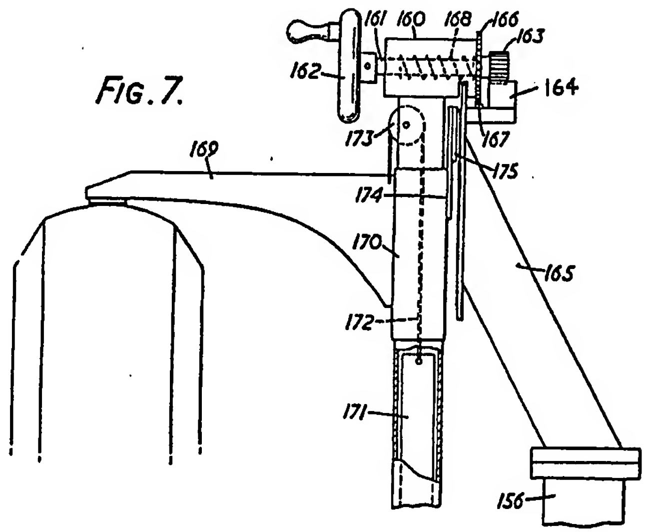


FIG. 7.

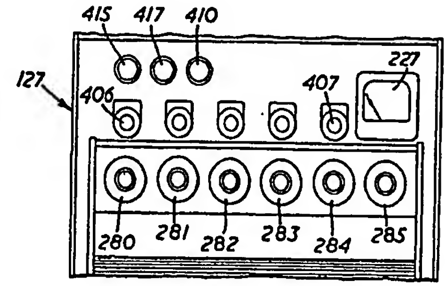
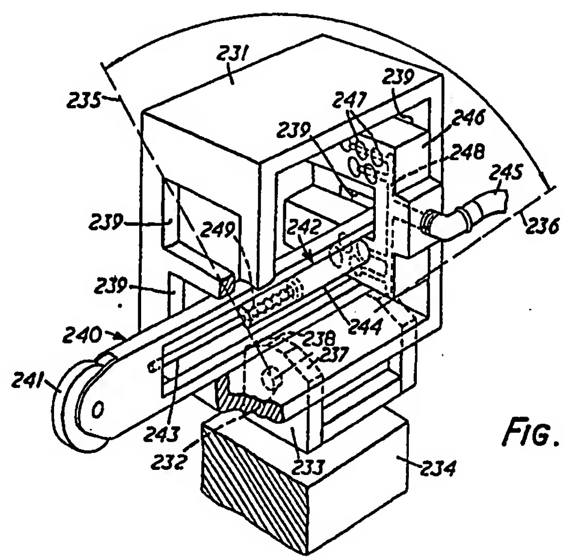


FIG. 10.



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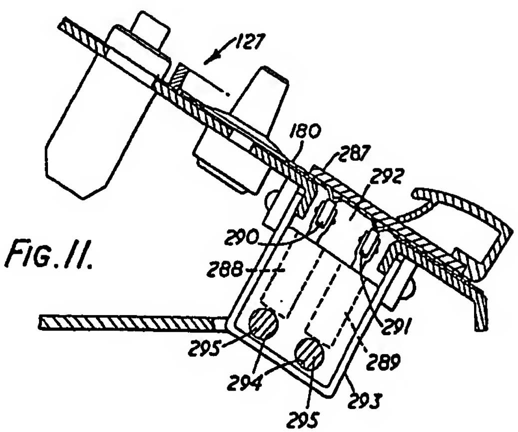


FIG. 11.

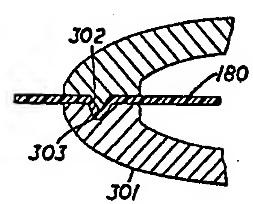
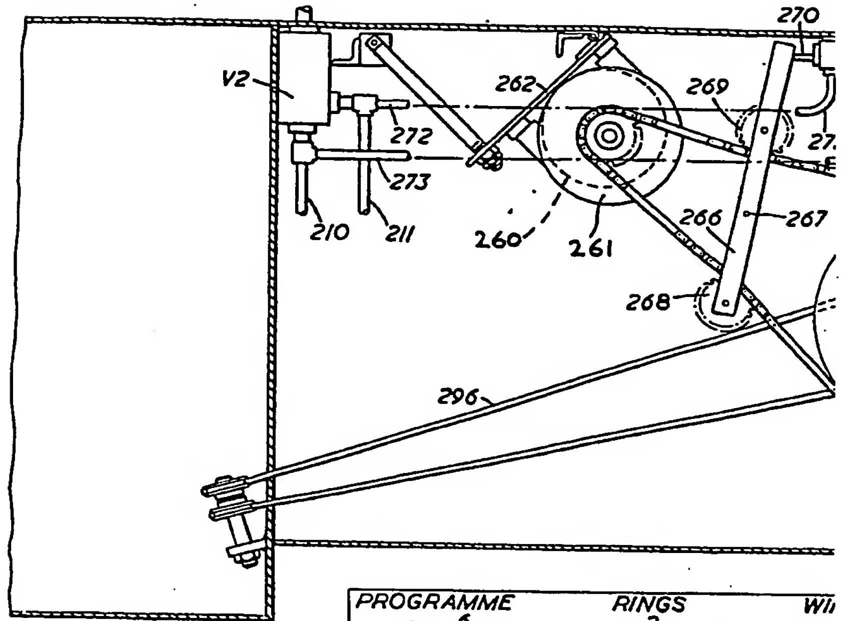
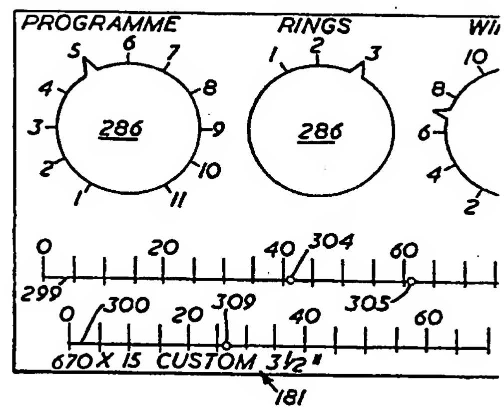


FIG. 13.





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CAM SW. #1						X	
CAM SW. #2							X
CAM SW. #3							
CAM SW. #4		X	X	X	X	X	X
CAM SW. #5	X			X			
CAM SW. #6	X				X		
CAM SW. #7							
HOME POSITION	1ST TURN	#1 BEAUTY RINGS	#2	#3	A SECT	B	

1,048,241 COMPLETE SPECIFICATION
17 SHEETS

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SHEET 5

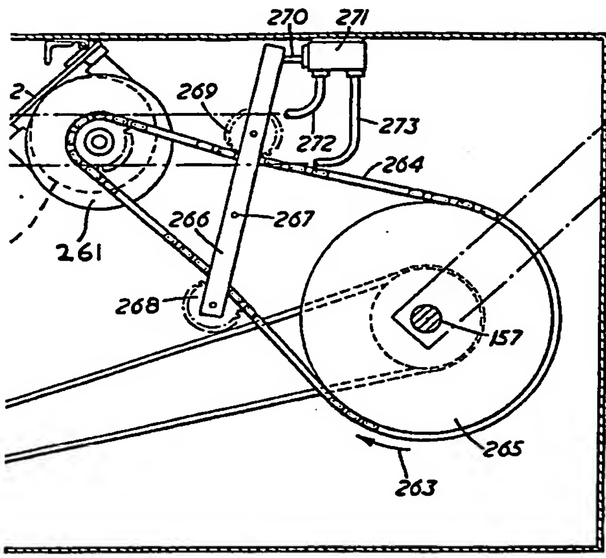


FIG. 9.

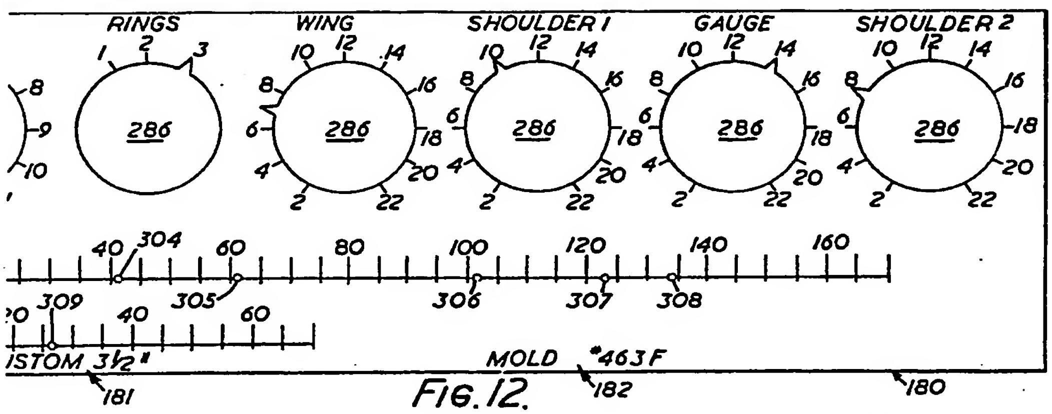


FIG. 12.

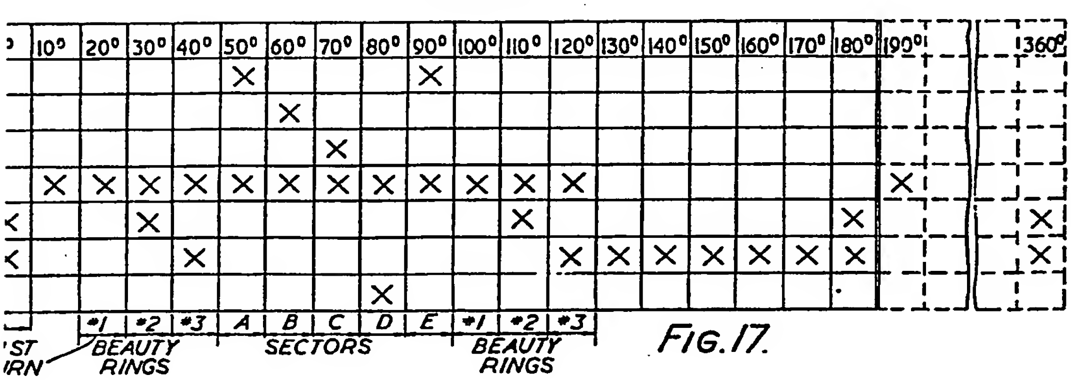


FIG. 17.

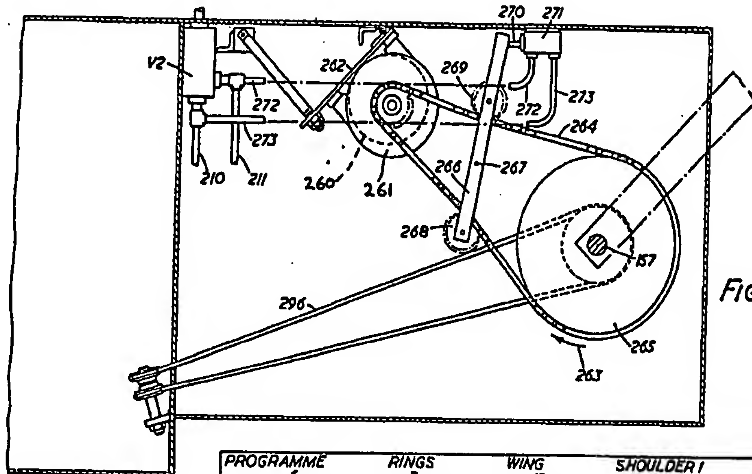


FIG. 9.

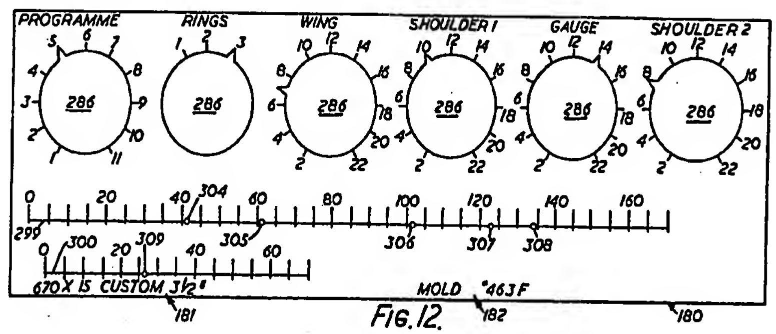


FIG. 12.

POSITION	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	190°	360°
CAM SW. •1						X				X											
CAM SW. •2							X														
CAM SW. •3								X													
CAM SW. •4		X	X	X	X	X	X	X	X	X	X	X	X							X	
CAM SW. •5	X			X								X							X		X
CAM SW. •6	X				X								X	X	X	X	X	X	X		X
CAM SW. •7									X												
HOME POSITION		1ST TURN	•1 BEAUTY RINGS	•2	•3	A SECTORS	B	C	D	E	•1 BEAUTY RINGS	•2	•3								

FIG. 17.

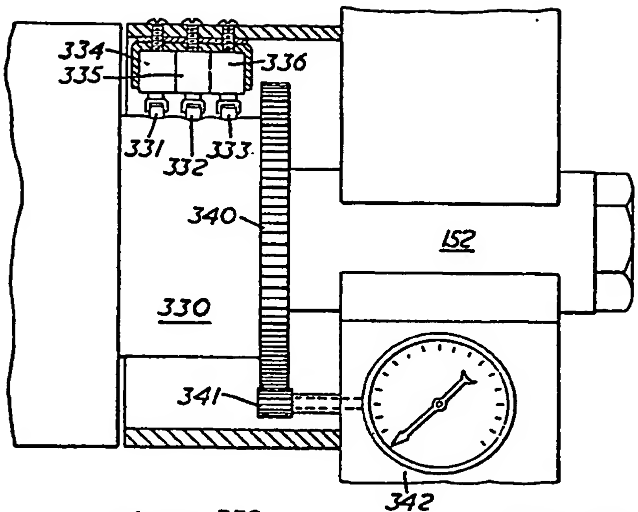


FIG. 14.

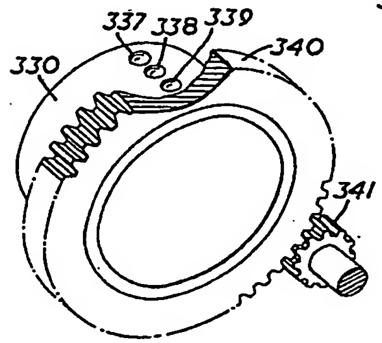


FIG. 15.

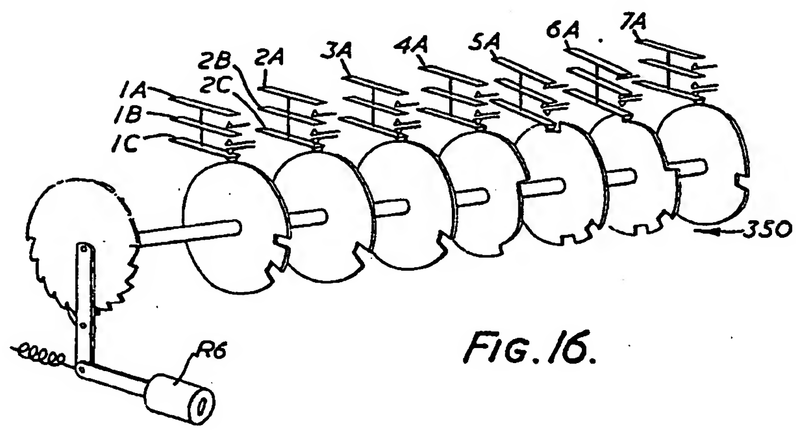


FIG. 16.

1,048,241 COMPLETE SPECIFICATION
17 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 7 & 8

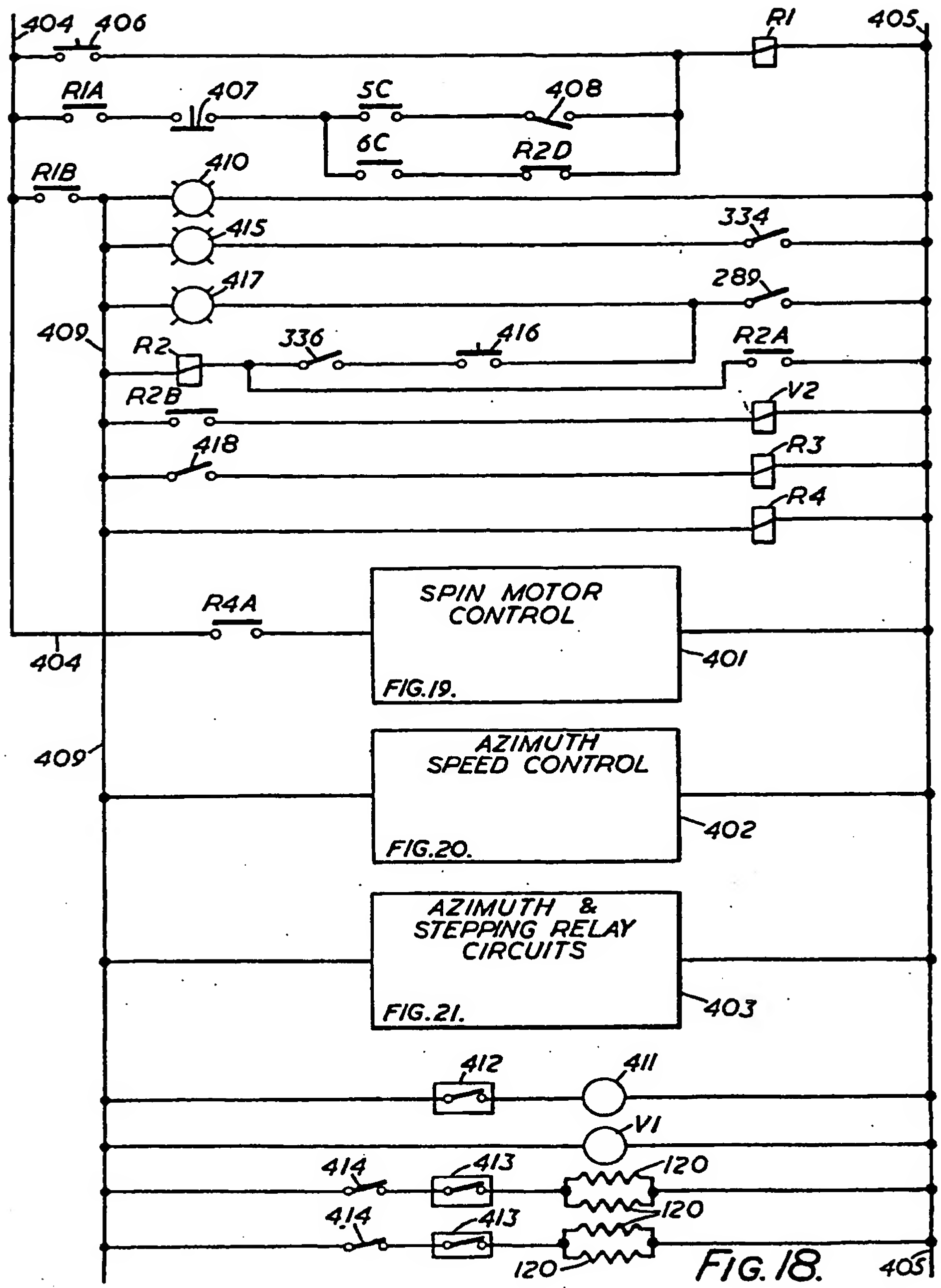
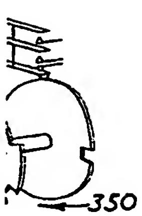


FIG. 18.



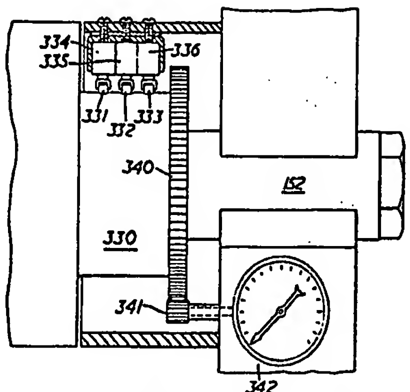


FIG.14.

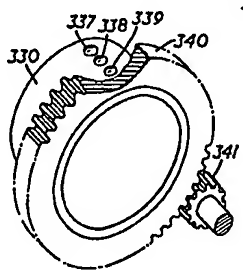


FIG.15.

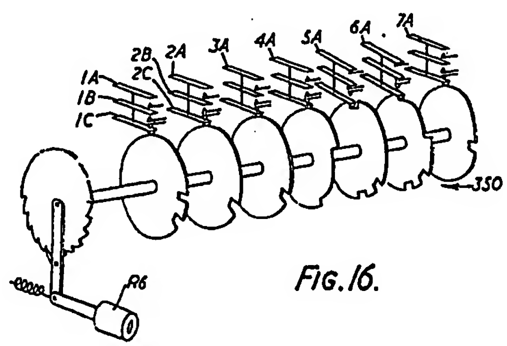


FIG.16.

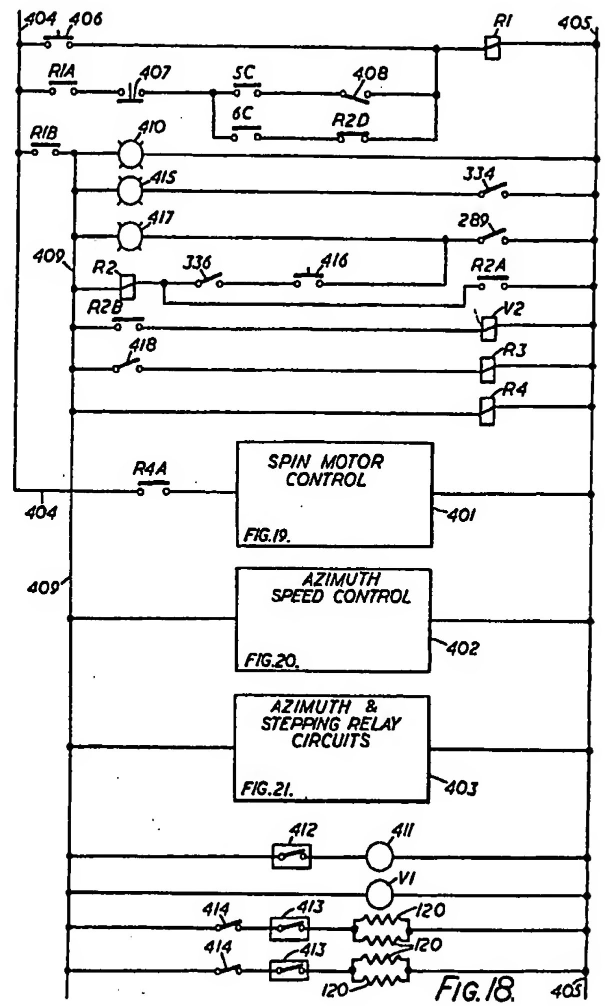


FIG.18.

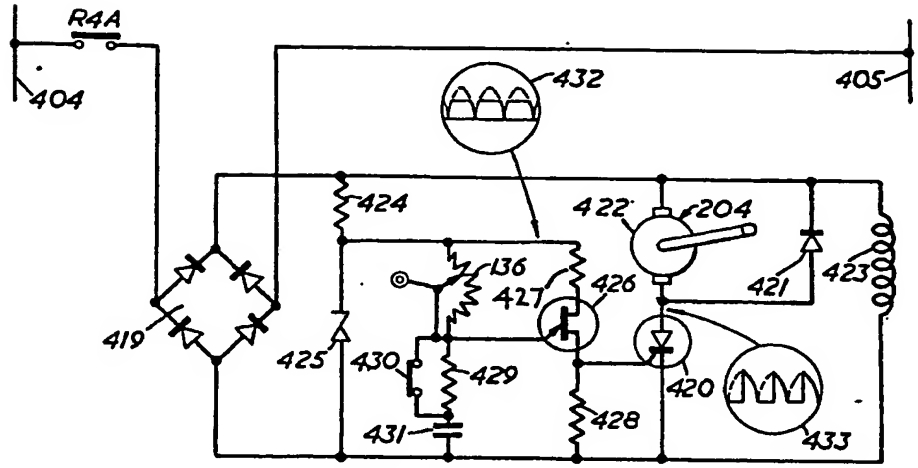

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FIG. 19.

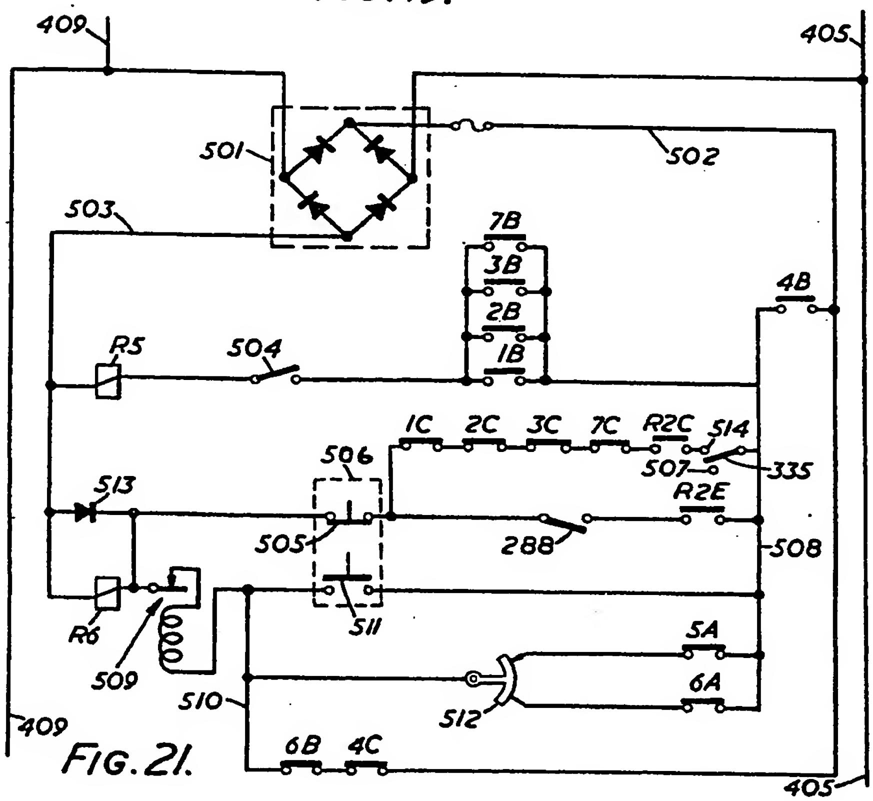
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FIG. 21.

1,048,241 COMPLETE SPECIFICATION
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SHEETS 9 & 10

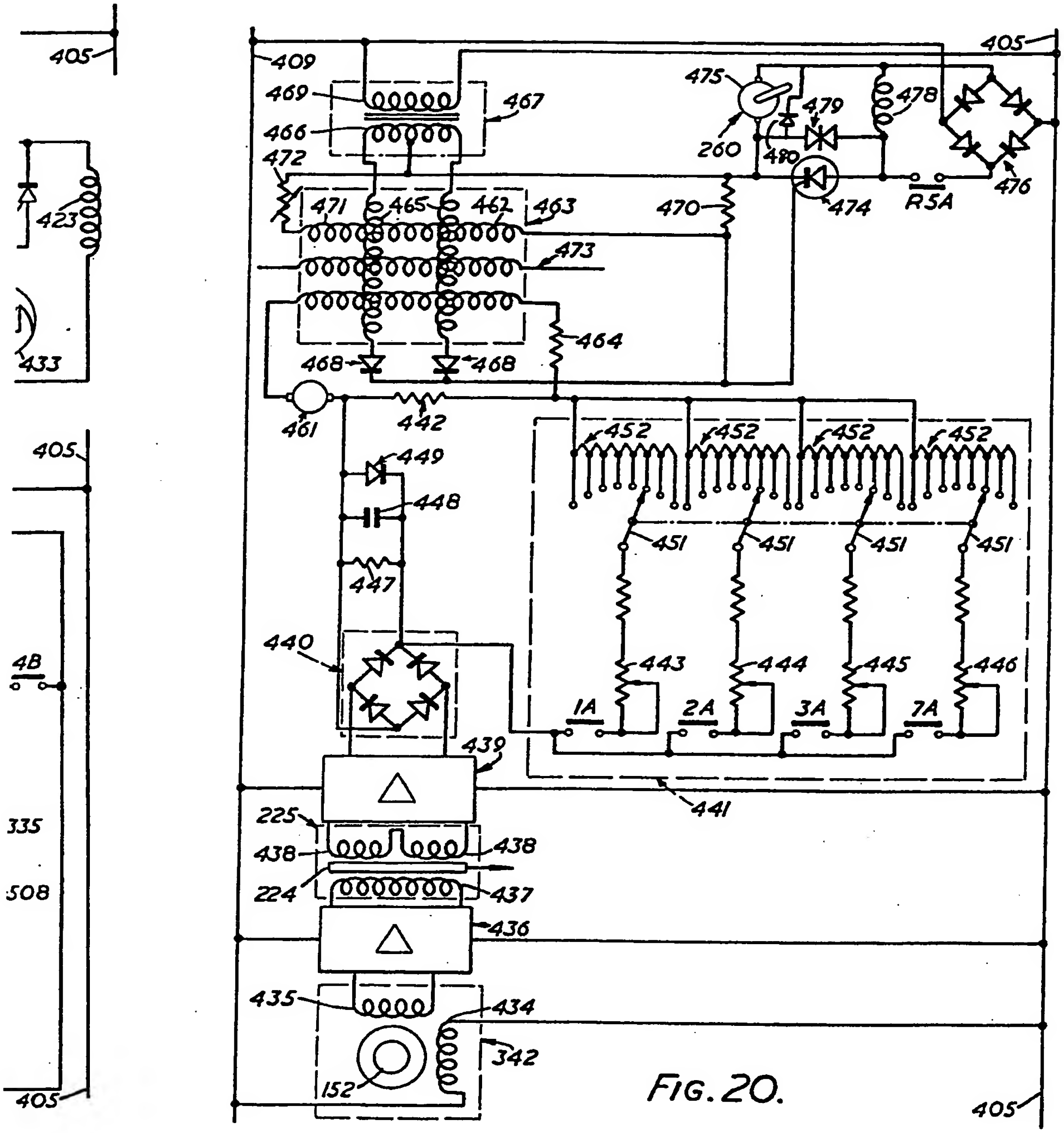

FIG. 20.

1,048,241 COMPLETE SPECIFICATION
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This drawing is a reproduction of the Original on a reduced scale.
SHEETS 9 & 10

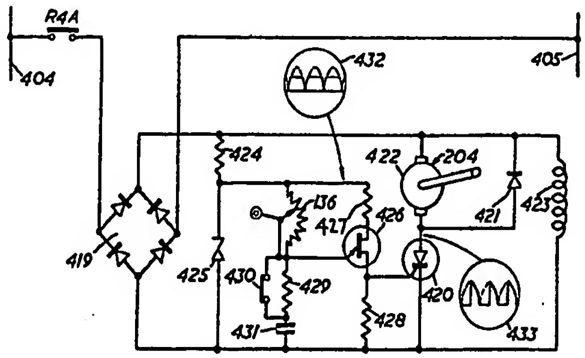


FIG. 19.

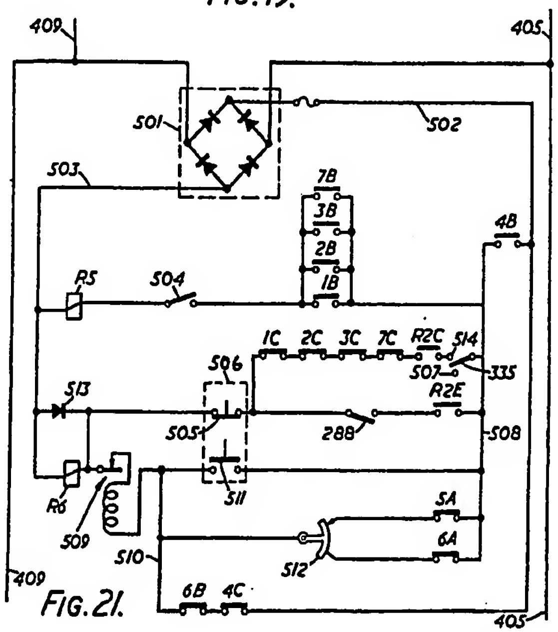


FIG. 21.

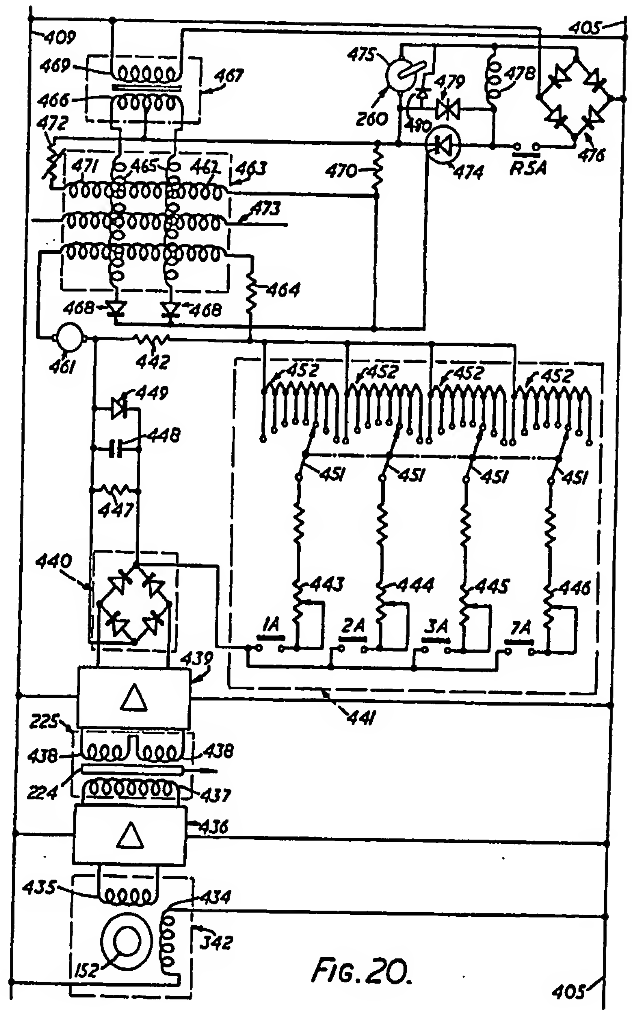


FIG. 20.

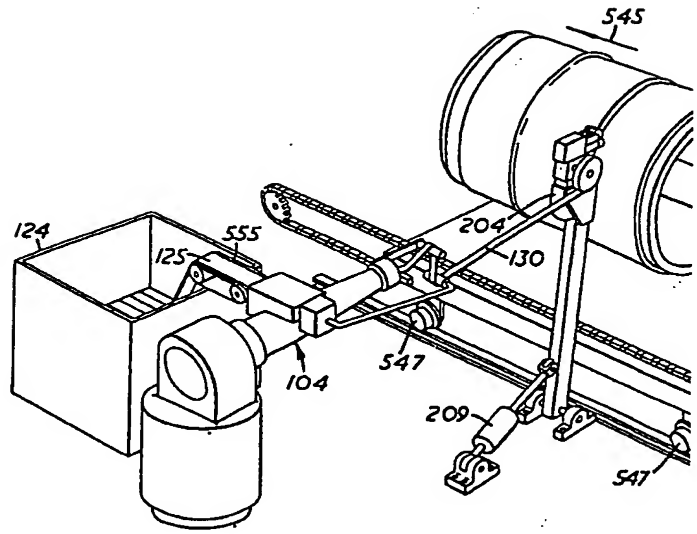


FIG. 22.

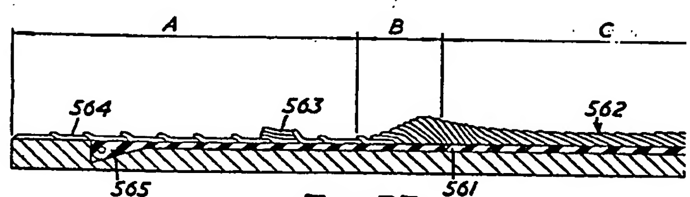


FIG. 23.

POSITION	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°
CAM SW. #1				X				X			
CAM SW. #2									X		
CAM SW. #3										X	
CAM SW. #4		X	X	X	X	X	X	X	X	X	X
CAM SW. #5	X					X					
CAM SW. #6	X						X				
CAM SW. #7											X
HOME POSITION		END OF 1ST TURN		A1	#1 BEAUTY RINGS	#2	#3	A2	B	C	D

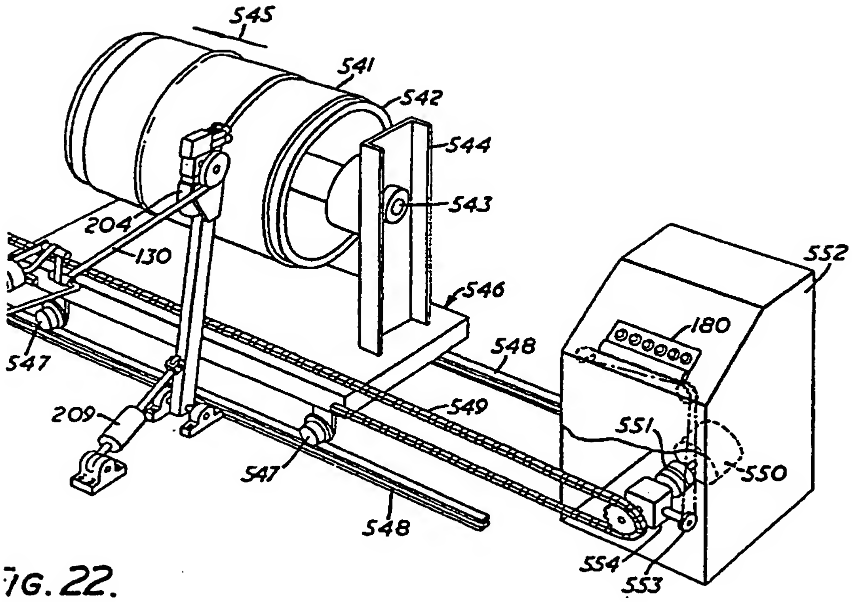
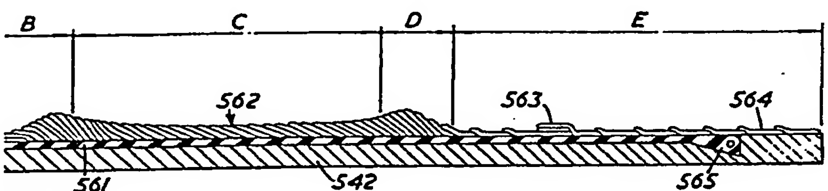
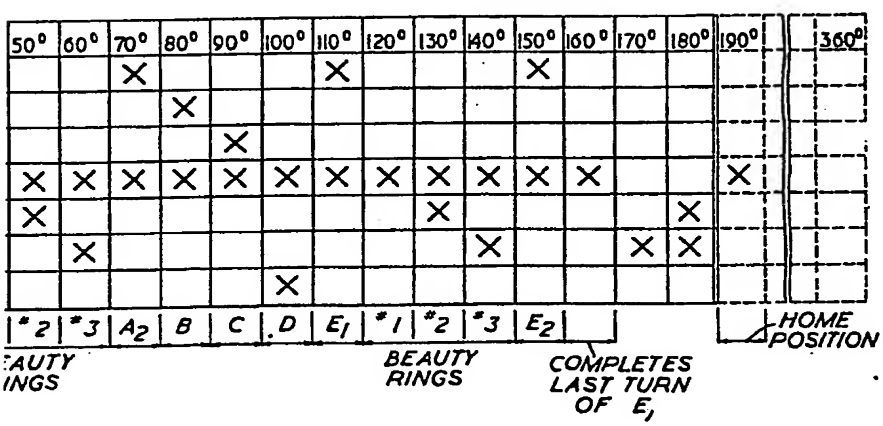


FIG. 22.



23.

FIG. 24.



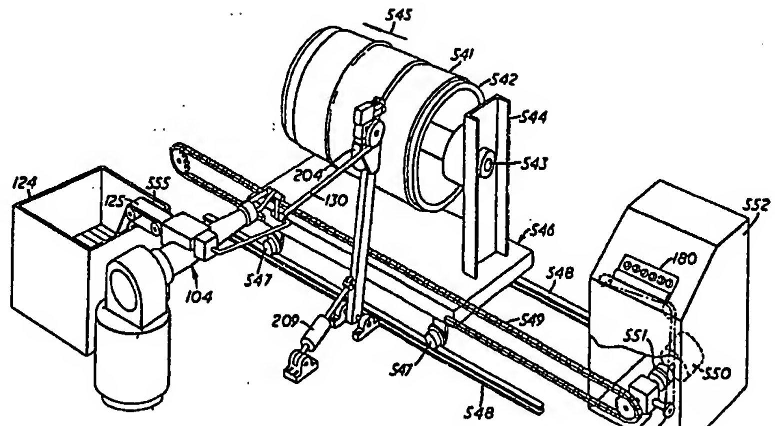


FIG. 22.

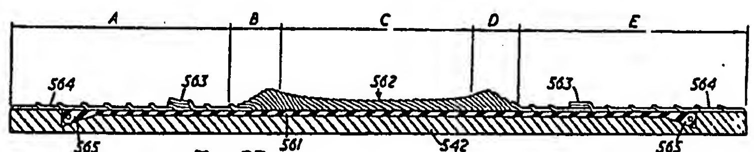


FIG. 23.

FIG. 24.

POSITION	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	190°		360°
CAM SW. #1				X				X				X				X						
CAM SW. #2									X													
CAM SW. #3										X												
CAM SW. #4		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		
CAM SW. #5	X					X								X					X			
CAM SW. #6	X						X								X			X	X			
CAM SW. #7											X											
				A_1	#1	#2	#3	A_2	B	C	D	E_1	#1	#2	#3	E_2						

HOME POSITION — END OF 1ST TURN — BEAUTY RINGS — BEAUTY RINGS — COMPLETES LAST TURN OF E_1 — HOME POSITION

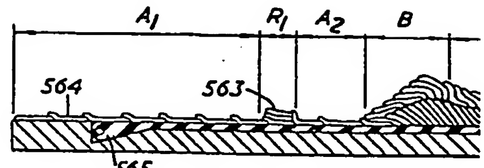


FIG. 25.

POSITION	0°	10°	20°	30°	40°	50°	60°
CAM SW. #1				X			
CAM SW. #2							
CAM SW. #3							
CAM SW. #4		X	X	X	X	X	X
CAM SW. #5	X					X	
CAM SW. #6	X						X
CAM SW. #7							
CAM SW. #8					X	X	X

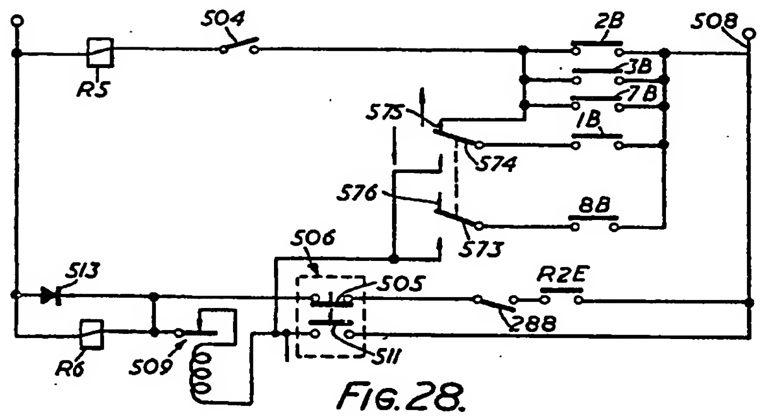
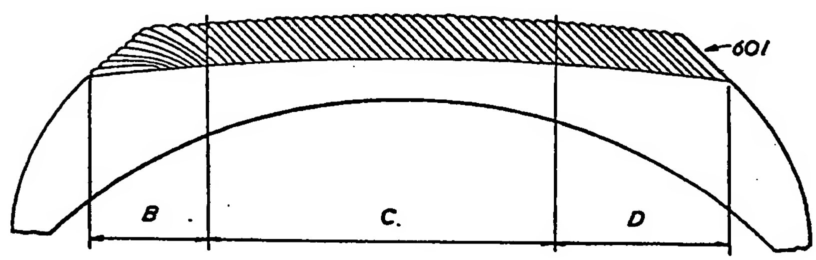


FIG. 28.



FIG

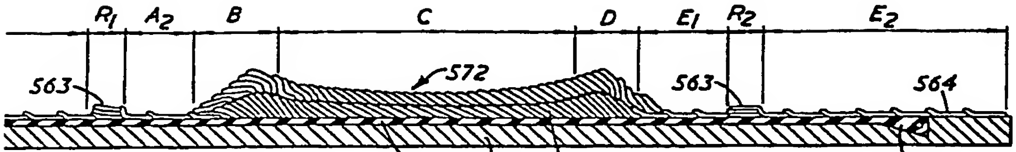
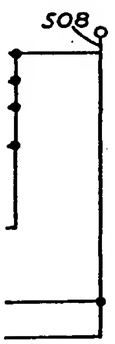


FIG. 25.

0°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	190°		360°
		X				X				X				X						
							X													
								X												
X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		
				X								X					X			
					X								X			X	X			
									X											
			X	X	X						X	X	X							

FIG. 27.



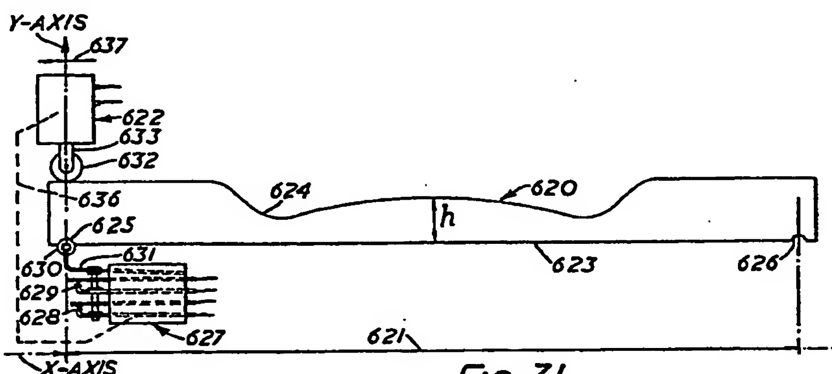


FIG. 31.

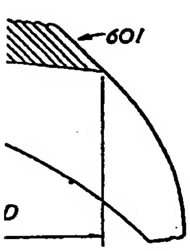


FIG 26

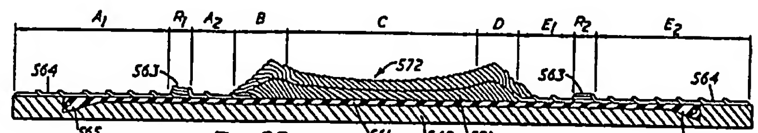


FIG. 25.

POSITION	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°	140°	150°	160°	170°	180°	190°		360°
CAM SW. 1				X				X				X				X						
CAM SW. 2									X													
CAM SW. 3										X												
CAM SW. 4		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X		
CAM SW. 5	X					X								X					X			
CAM SW. 6	X						X								X			X	X			
CAM SW. 7											X											
CAM SW. 8					X	X	X						X	X	X							

FIG. 27.

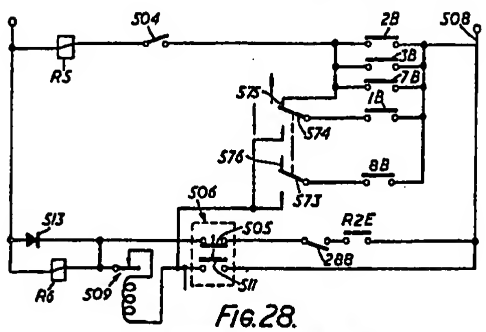


FIG. 28.

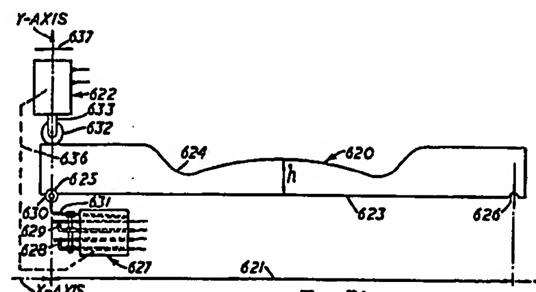


FIG. 31.

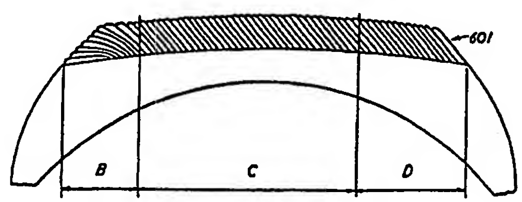


FIG 26

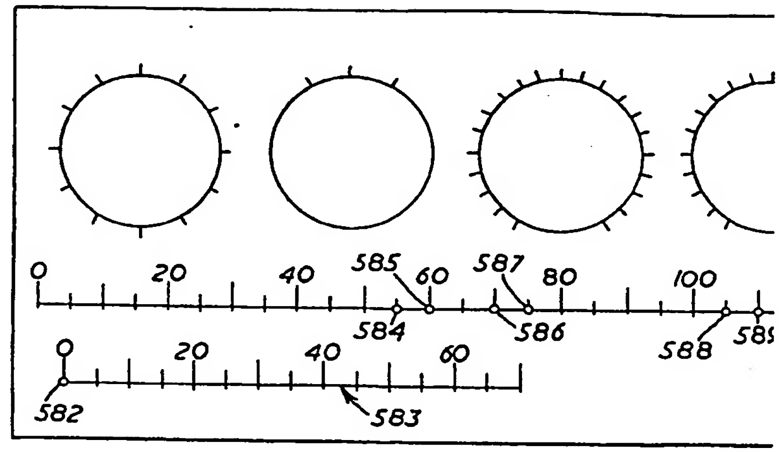


FIG. 29.

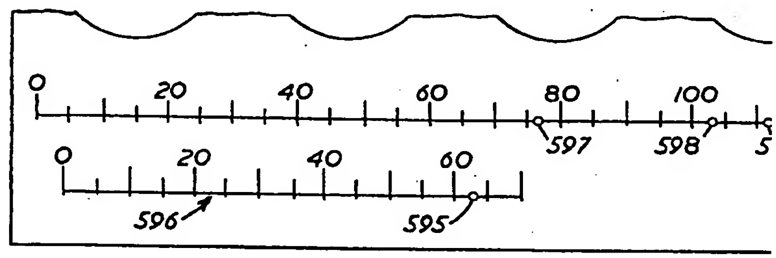


FIG. 30.

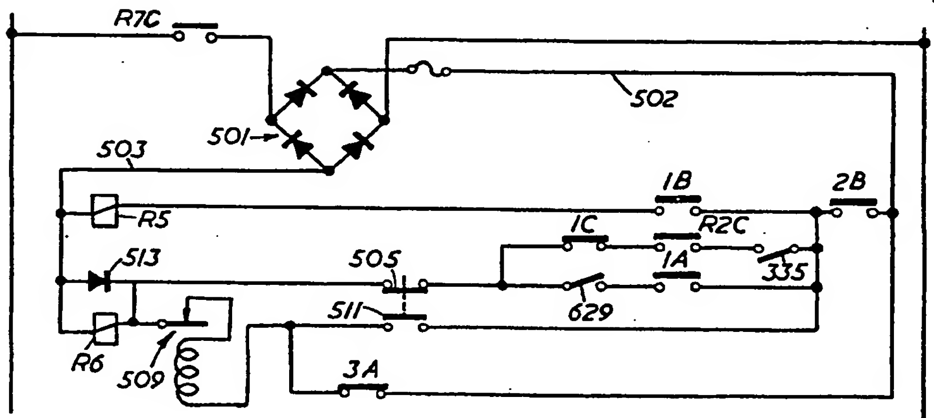


FIG. 34.

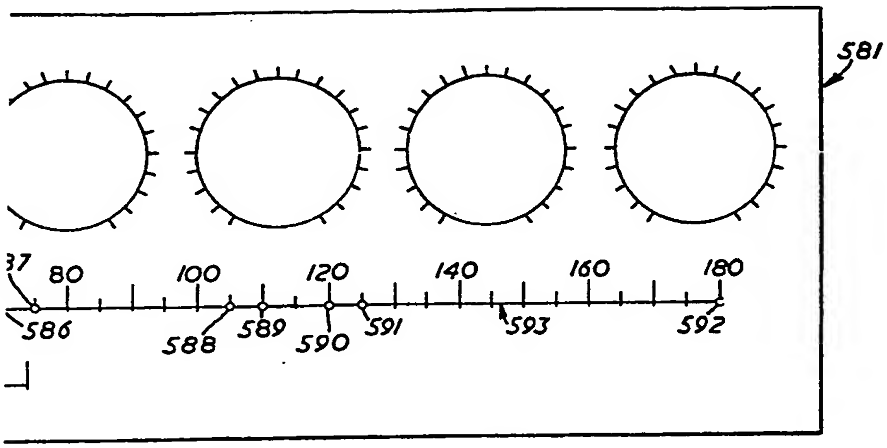


FIG. 29.

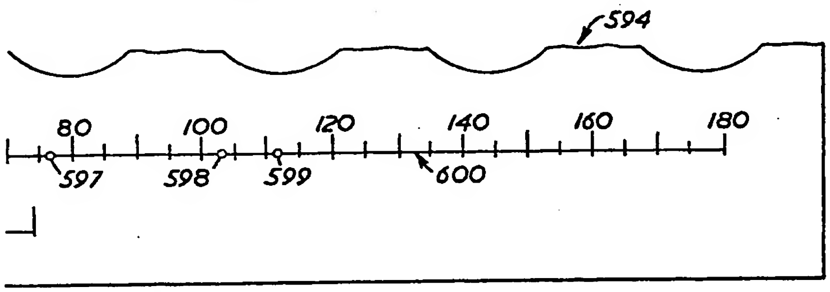
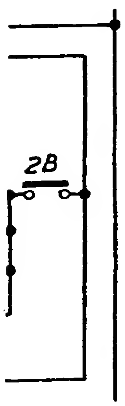


FIG. 30.



	0°	10°	20°	30°	40°	
CAM #1			X			
CAM #2		X	X	X		
CAM #3	X				X	

HOME TURN
1ST TURN
COMPLETE WINDING EXCEPT 1ST AND LAST TURNS
HOME TURN
LAST TURN

FIG. 35.

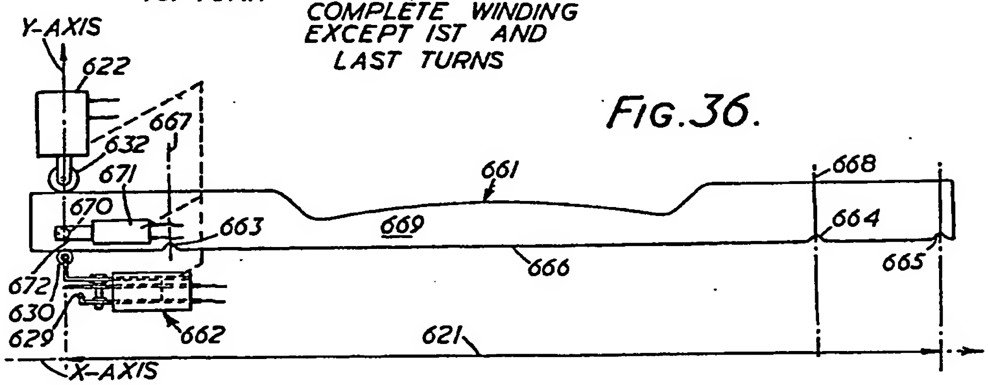


FIG. 36.

COMPLETE SPECIFICATION
This drawing is a reproduction of the Original on a reduced scale.
SHEET 13

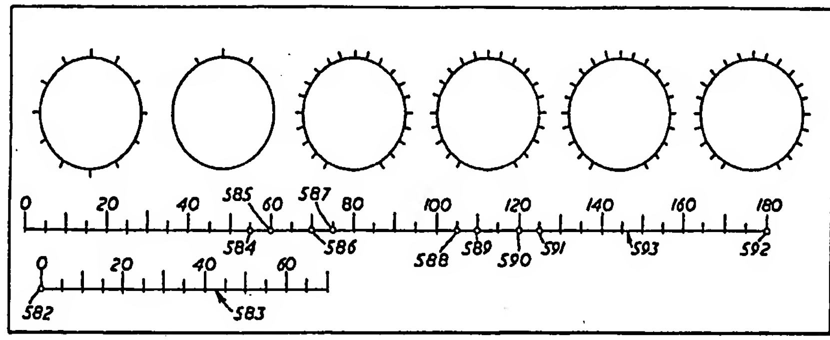


FIG. 29.

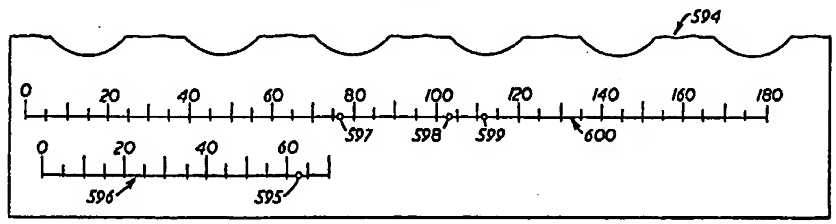


FIG. 30.

	0°	10°	20°	30°	40°	
CAM #1			X			
CAM #2		X	X	X		
CAM #3	X				X	

HOME TURN
1ST TURN
COMPLETE WINDING EXCEPT 1ST AND LAST TURNS
HOME TURN
LAST TURN

FIG. 35.

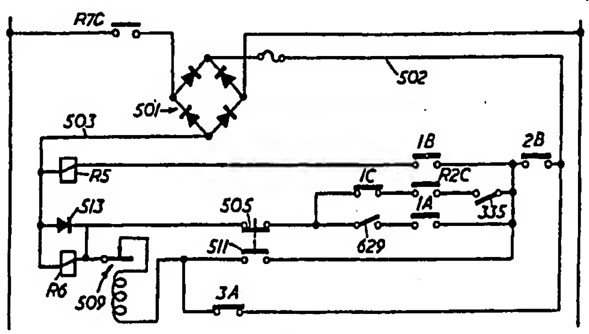


FIG. 34.

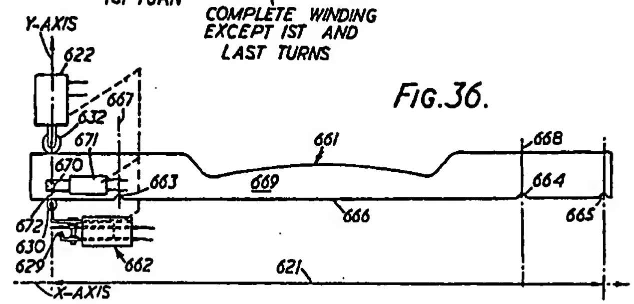
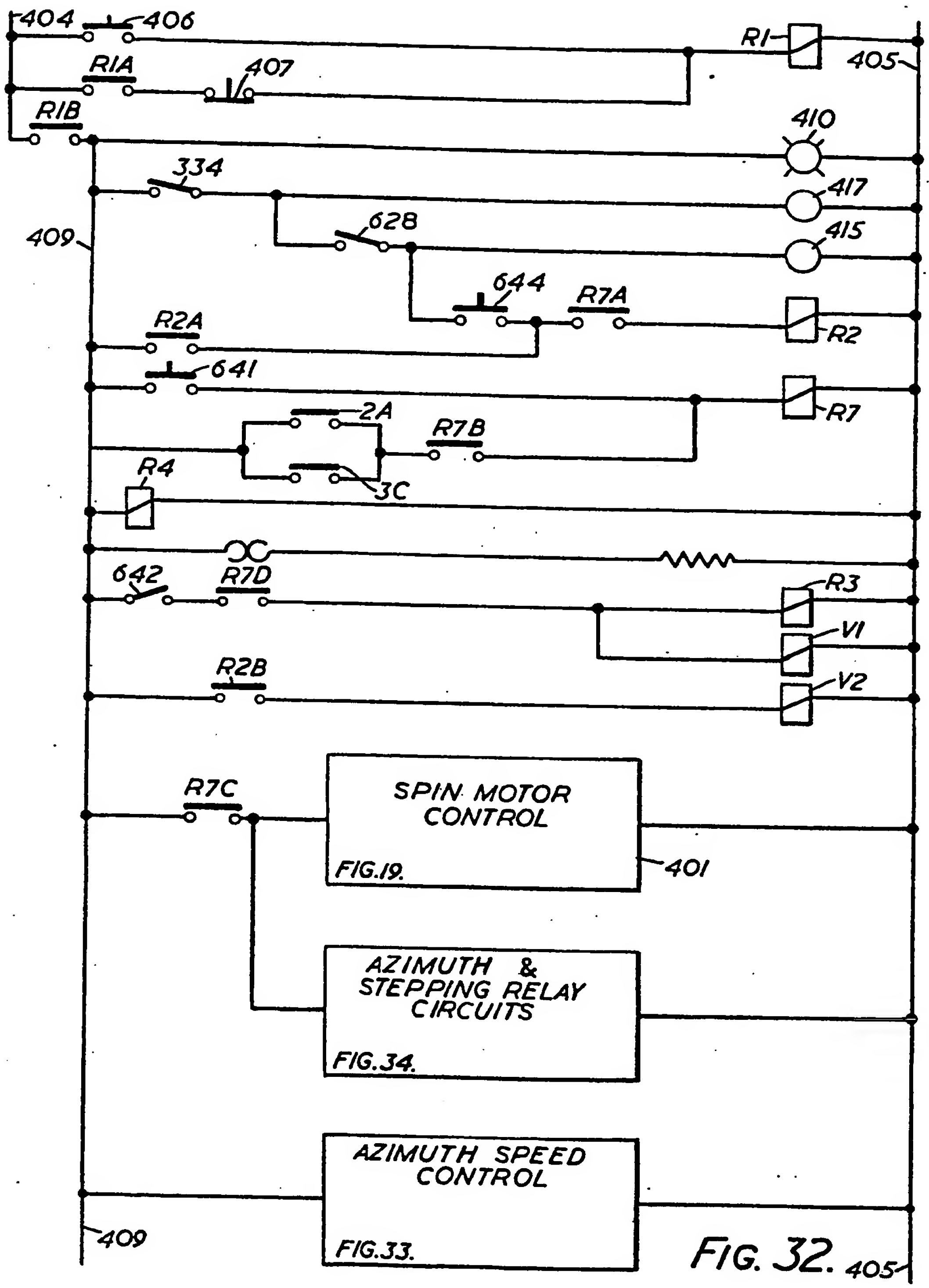
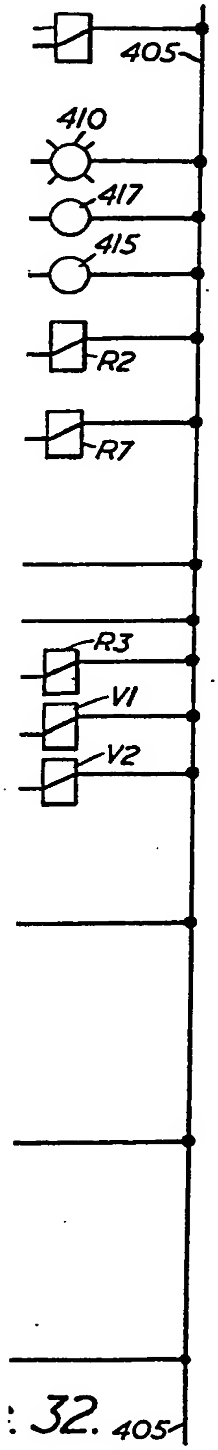


FIG. 36.


404
406
R1
405
R1A
407
R1B
410
334
417
409
628
415
644
R7A
R2A
R2
641
R7
2A
R7B
R4
3C
642
R7D
R3
V1
R2B
V2
R7C
SPIN MOTOR CONTROL
FIG.19.
401
AZIMUTH & STEPPING RELAY CIRCUITS
FIG.34.
AZIMUTH SPEED CONTROL
FIG.33.
409
405
FIG. 32.

1,048,241 COMPLETE SPECIFICATION
17 SHEETS
This drawing is a reproduction of the Original on a reduced scale.
SHEETS 14 & 15



: 32.

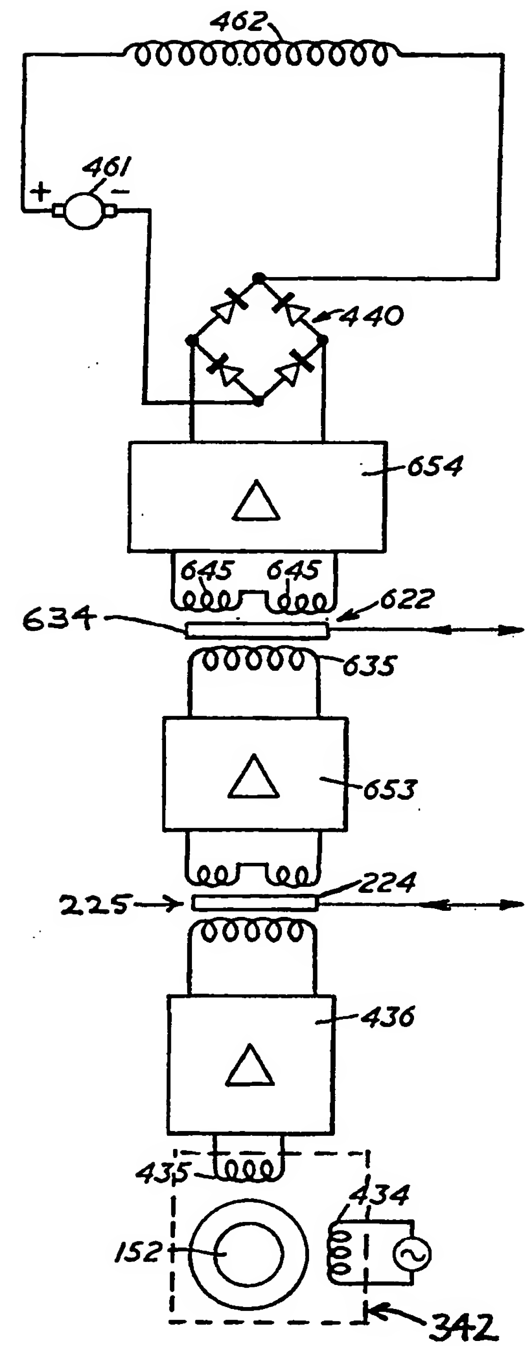


FIG. 33.

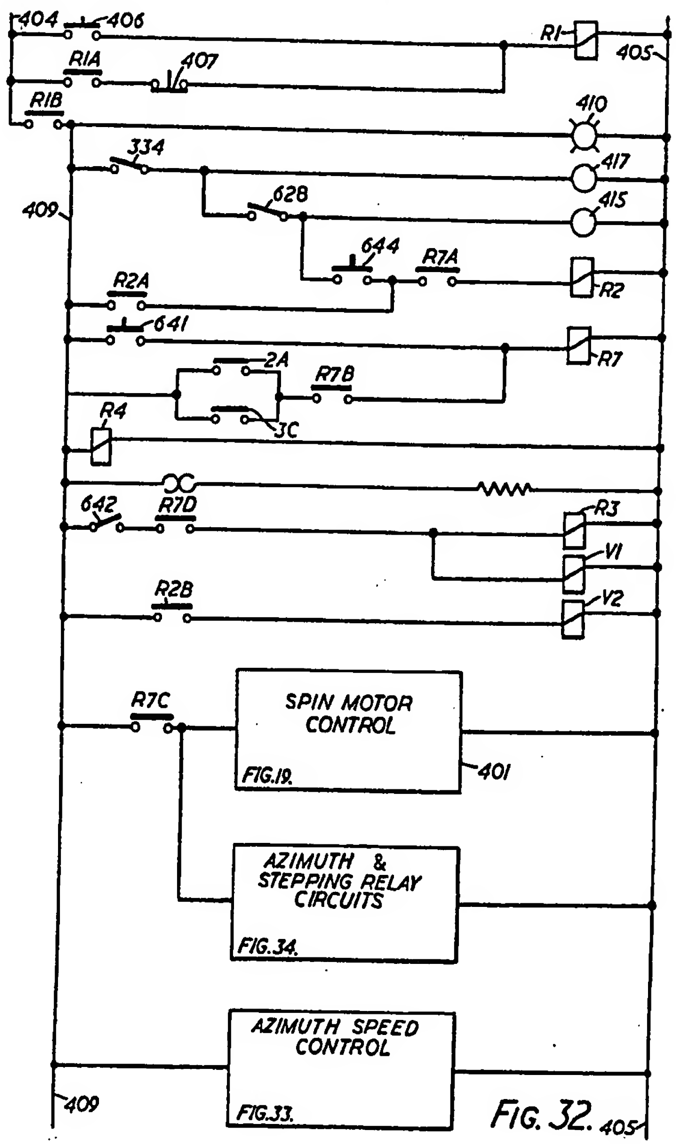

404
406
RIA
407
RIB
RI
405
410
417
415
334
628
409
644
R7A
R2
R2A
641
R7
2A
R7B
3C
R4
642
R7D
R3
V1
V2
R2B
R7C
SPIN MOTOR CONTROL
FIG.19.
401
AZIMUTH & STEPPING RELAY CIRCUITS
FIG.34.
AZIMUTH SPEED CONTROL
FIG.33.
409
405

FIG. 32.

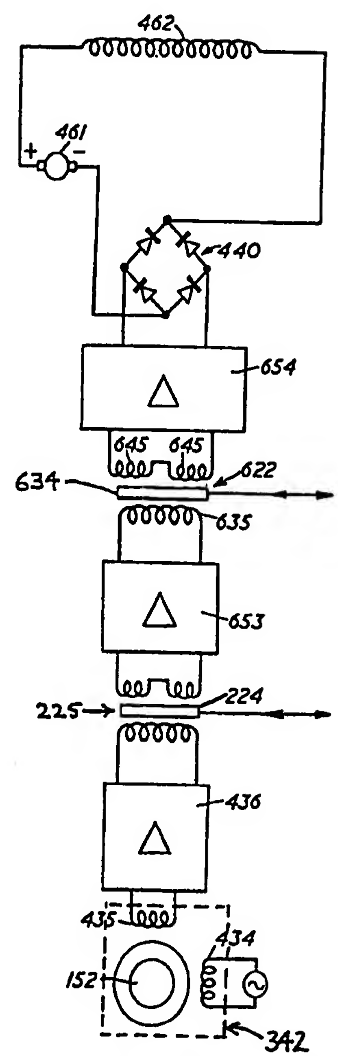

462
461
+
−
440
654
645
645
634
622
635
653
225
224
436
435
434
152
342

FIG. 33.

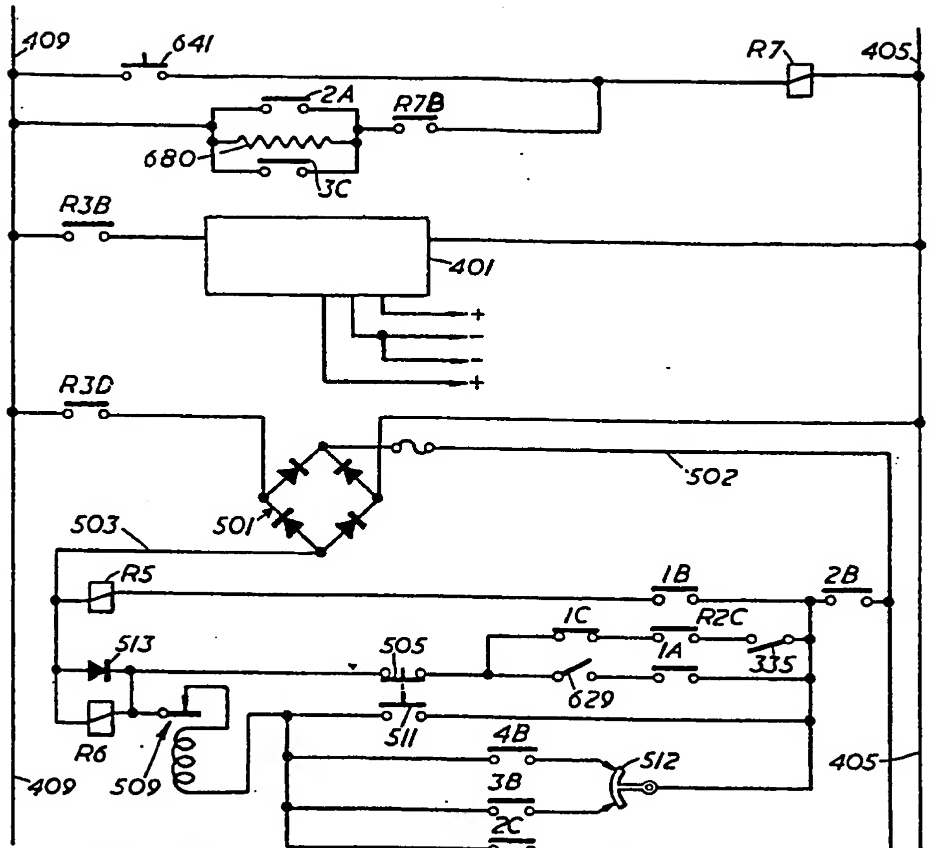


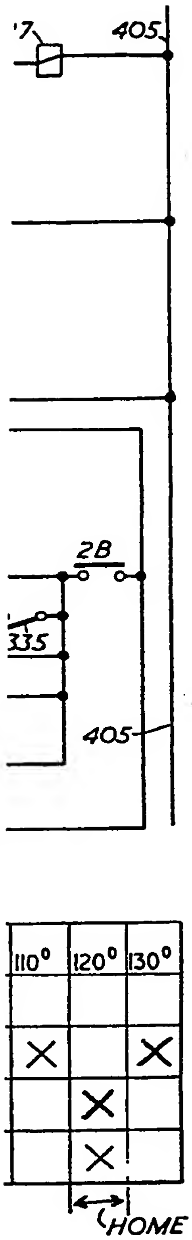
FIG. 37.

	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°
CAM #1			X				X				X			
CAM #2		X	X	X	X	X	X	X	X	X	X	X		X
CAM #3	X					X				X			X	
CAM #4	X				X				X				X	

HOME HOME

FIG. 38.

1,048,241 COMPLETE SPECIFICATION
17 SHEETS This drawing is a reproduction of the Original on a reduced scale.
SHEETS 16 & 17



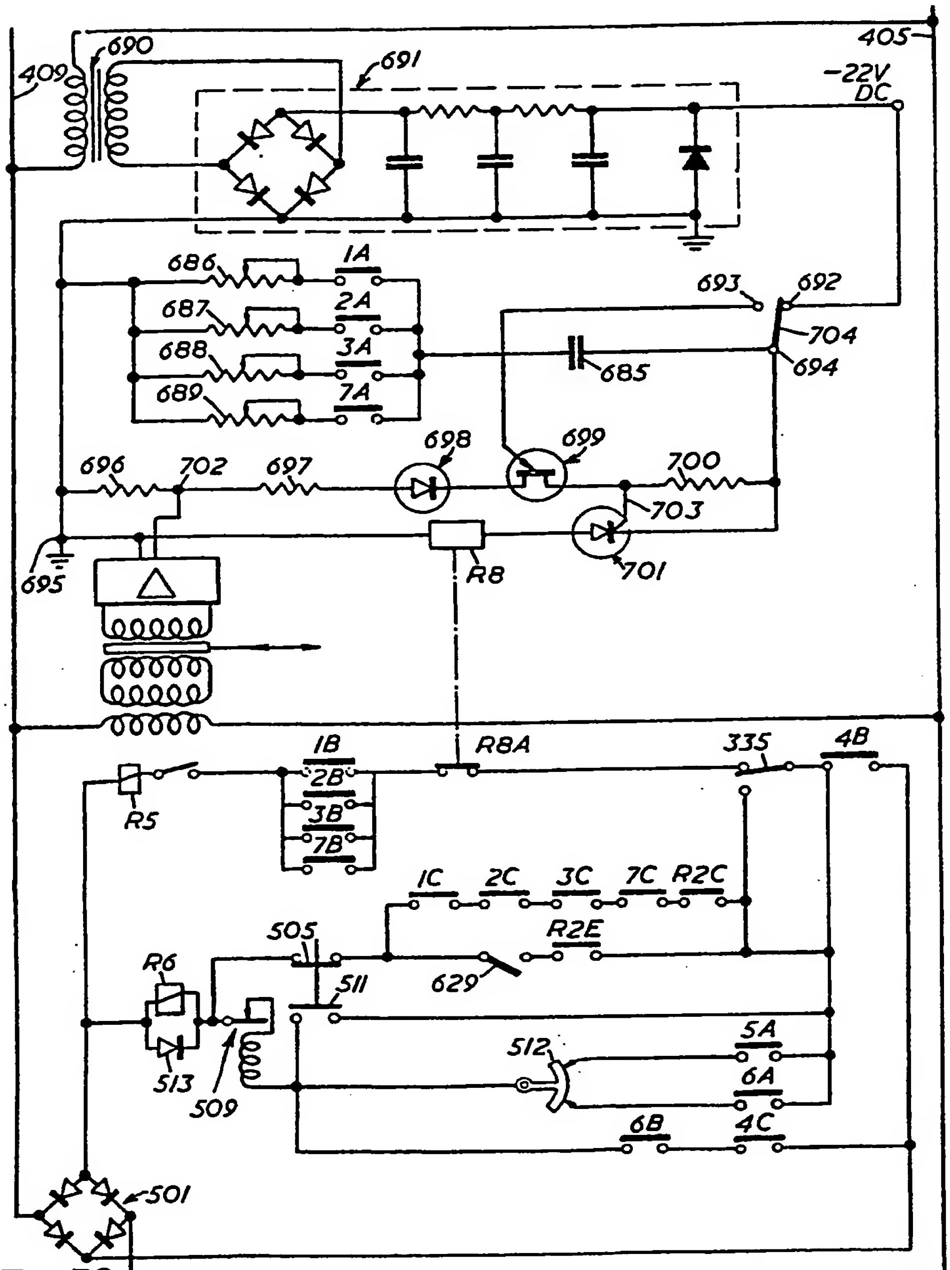


FIG. 39.

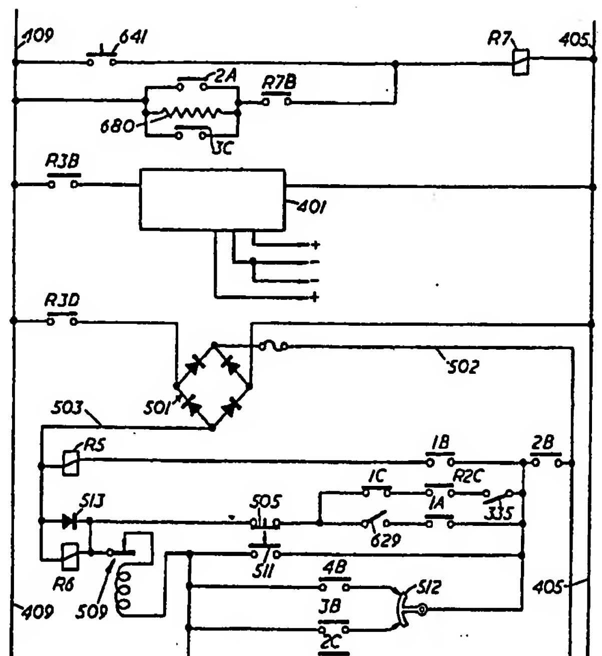


FIG. 37.

	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°	110°	120°	130°
CAM °1			X				X				X			
CAM °2		X	X	X	X	X	X	X	X	X	X	X		X
CAM °3	X					X				X			X	
CAM °4	X				X				X				X	

HOME HOME

FIG. 38.

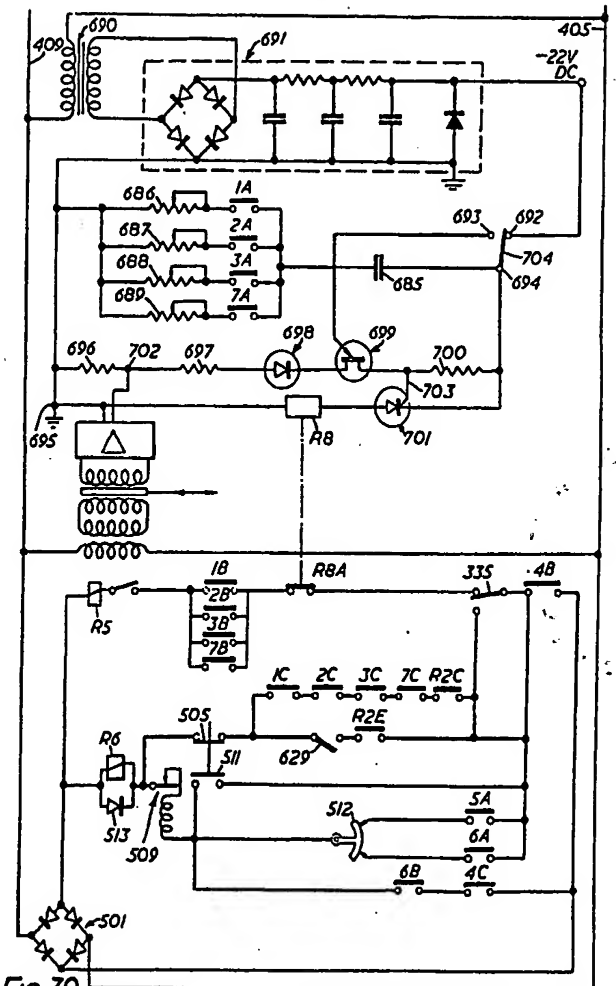


FIG. 39.